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Publisher's Letter

Cruise ships are technical marvels

Just recently I took a short break and travelled on the *Radiance of the Seas*, down the east coast of Australia. This was my third cruise and each time I have come away mightily impressed by the fantastic range and depth of technology employed on these floating cities. The amount of technology in use affects virtually every ship-board operation and most of it is largely invisible to the passengers (because large areas of the ship are simply off-limits to passengers). And of course, even where it is clearly on view, the technology and its complexity is seldom understood or even noted by the vast majority of the passengers.

The *Radiance of the Seas* was particularly interesting for me because it uses two 25MW gas turbines for propulsion. Most large cruise ships use two huge diesel engines. The gas turbines drive alternators which then power two 20MW electric pod drives at the stern. These can be turned to face in any direction so they can double as stern thrusters as well as being able to drive the ship in forward and reverse.

But the gas turbines are used in a closed cycle, much like gas-fired closed cycle power stations which have the gas turbines drive alternators directly and then their exhaust heat drives a boiler to generate steam and drive another alternator. In the case of the *Radiance*, the exhaust heat drives a 7.8MW steam turbine to generate electricity. For the passengers, the most apparent benefits of the gas turbines were the absence of vibration which is always present in a ship with large diesel engines, and the lack of diesel fumes.

Apart from propulsion, lighting and air-conditioning, the ship also has evaporators and reverse-osmosis desalination to produce the huge quantities of fresh water needed every day. As well, all sewage and waste water must be processed to a high standard before being discharged overboard and waste food is macerated before it too is discharged overboard. Other heavy electrical loads are the eleven elevators throughout the ship and of course, the ship's kitchens and laundry which must cater for up to 3300 passengers and crew.

Apart from that, there are the complex systems which provide for public address, surveillance and fire safety all over the vessel, video entertainment, WiFi (in every cabin but you have to pay to use it!), all the systems in the casino, all the entertainment systems in the bars, dining rooms, gymnasium and so on.

I should not forget the stabilisers which are a standard feature of every cruise ship. On the *Radiance* these are two 7-metre wings which protrude below the water line and which swivel constantly to "fly" the hull through the water as it powers along. Without them, cruising as we know it would be a far less comfortable exercise.

One piece of technology which was clearly on view and appreciated by those passengers who used it was employed in the pool tables which are gyroscopically stabilised. It works extremely well even though those who played pool found it quite a disconcerting experience as the tables moved markedly, to compensate for movement of the ship.

So what was the most impressive feature? Clearly, this was on show each time the ship slowly berthed when it came into port and when it departed each evening. It was awe-inspiring to watch as the 100,000 tonne vessel silently inched up to the pier, propulsion pods and bow thrusters intermittently operating, all under the control of a joystick and not a tug in sight!

But the best moment for me was when the ship was leaving the International Terminal at Sydney's Circular Quay. As the ship came abreast of the Opera House the fog-horn gave an almighty blast. Now that was a wonderful adrenalin-charged moment! But that is old fashioned technology, isn't it?

Leo Simpson

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Metal halide lamps are not expensive

With regard to your article on replacing high-bay industrial lighting with LEDs, I'd like to make the following comments:

(1) You quote 22,000 lumens for the output of a 400W mercury lamp. That's the output on day one. It steadily declines. You should replace them when it drops to 14,000 lumens. Replacement is more often due to that than failures.

(2) These days "mercury" lamps of that sort often aren't, unless they are old. They are metal halide. Real mercury lamps are progressively becoming illegal in more and more parts of the world. One of the issues in replacing overhead lamps is whether the fitting will only operate with a mercury bulb, can take either sort or requires a metal halide globe. They tell you it's written on the fitting. But you've got to get up there to read it to find out or know how to tell the difference from the shape of the bulb that's fitted.

(3) Neither mercury nor metal halide globes are in fact "expensive" as the article claims. Twenty to thirty dollars for a 400W globe is not expensive.

(4) You don't have to get a scissor lift to change mercury or metal halide globes. You can get a long rod with a spring loaded elasticised fitting on the end that you can reach up from the floor and fit around the globe, and as you turn it, it grips the bulb and unscrews it. And it screws the new globe in. A lot of places that have these sorts of lights simply couldn't clear the floor of equipment and bring in a scissor lift and park it directly under each light fitting.

(5) With that ease of changing lamp bulbs and the low cost of bulbs, changing to LEDs, for all their benefits, is not worthwhile for a lot of places. It's far cheaper to pay for more electricity used than spend tens of thousands of dollars clearing the floor, hiring a scissor lift and an electrician, shutting down your business for the duration, and replacing all the mercury or metal halide fittings with LED fittings.

(6) But for a new installation you'd be crazy not to go LEDs. You do have to remember though that when one does eventually fail you probably will have to spend a lot of money replacing not just the equivalent of the globe (the LED element) but also the whole fitting. That very significantly affects which is the better proposition in the long term.

(7) Mercury and metal halide fittings – meaning the ballast – are passively cooled. LED fittings and elements can't operate at high temperatures. They are often fitted with a fan. That fan is a source of unreliability. Small wattage high-bay LED fittings don't require fans but you have to install and replace more of them. Bigger units may have fans and may fail prematurely in some environments because of that.

Suggested modifications for the GPS Tracker

Having built the GPS Tracker which was featured in the November 2013 issue, I have a few hints which might come in handy for other constructors, daring to deviate from the original.

First, when using the EM408 receiver, do not stick this receiver with double-sided sticky tape atop the SD card cage. This is tempting but one shock later and the cage is destroyed.

Instead of the down-converter, I used a LM7805 plus two 1N4148 diodes to get the 3.3V supply. The 7805 needs a small heatsink like TV5, 25°C/W or better.

When using the unit from a battery, put a 10kΩ resistor from +V to 0V to get the Tracker to write and close the file when the power is removed, otherwise a back feed from the 7805 will prevent a proper low logic level to be presented to the microcontroller.

Ben Heij,
Little Mountain, Qld.

Geoff Graham comments: firstly, I agree that using double-sided tape for fastening the EM408 is not the best mounting method. A better approach would be to sandwich the module between two pieces of foam which will hold it securely when the lid is screwed down.

Your suggestion for the linear power supply will not work in the long term. The power supply was designed to be as efficient as possible and to keep the 3.3V supply up for as long as possible after the 12V supply is removed (as explained in the article).

A lot of testing went into this and during this phase, simpler solutions using a linear regulator were rejected. Your modification might work now but it will be marginal and will not give enough time to save and close the files if the battery voltage is low, or if there are a number of files to close or when the 4700µF capacitor has aged and lost some of its capacitance. As a result some files will be recorded with a zero file length and your computer will report that the file system on the SD card is corrupted.

Finally, the 10kΩ resistor is not required when the GPS Tracker is connected to a car battery as the car's electrical system will promptly pull the 12V power to ground. You were probably testing it using a bench power supply and shutting it down by open-circuiting the power to the Tracker. In that case a pull-down resistor would be required.

Car radios have good AM reception

I was interested to see the Mini Entertainment Unit project in the February edition. I live 100km north-east of Perth in a house that is comprehensively RF shielded. It is steel-framed with foil 'sarking' in all the walls, foil-lined insulation under the floor, foil-lined 'air-cell' lining under the roof and a corrugated metal roof.

While the window apertures allow some FM reception, AM is impossible. Being aware of the fact that reception was good in car radios, I bought a cheap one from JB Hi-Fi. In this case, I wired it to the speakers in an old defunct cassette/radio. I ran an extended antenna lead through the wall via a wall-plate and up to a car radio antenna mounted on the verandah roof. The radio is powered by a 12V 1A regulated plugpack.

While not 'hifi', it gives reasonable sound and good clear AM reception. This is particularly important in summer-time when the Perth ABC stations broadcast regular bushfire status updates.

Joe Edgecombe,
Coondle,WA.

(8) If I was replacing mercury or metal halide lighting with LEDs I'd look first at "street light" type fittings rather than high-bay fittings. Many of the street light ones have lots of LEDs run in series so they can be connected directly to the mains voltage so they are as reliable as the LED elements – rather than that reliability being reduced by an electronic "ballast" that will fail sooner; much sooner if it overheats.

Gordon Drennan,
Burton, SA.

E-cigarette criticism is unwarranted

I would just like to say, what a lot of pessimistic, uneducated, one-sided piffle the Publisher's Letter on E-cigarettes in the February 2014 issue was. It was full of personal opinions, very little fact and a bunch of propaganda thrown in. You are openly calling people delusional.

Not all users of Personal Vapourisers smoke with nicotine. How can you assume that, with zero knowledge of peoples' personal usage? If you knew anything about the people who use them, you probably wouldn't listen anyway, due to your closed-mindedness of what is the best NRT (nicotine replacement therapy) ever.

Now, let's assume that a person is using a liquid that contains nicotine. Do you know anything about the nicotine levels in these juices? What does "to contain nicotine" mean to you? You have no idea is the answer, as the nicotine levels in these juices, even in high concentrations, are still less than what is in the equivalent usage of a cigarette.

You make no mention of the fact that sale of nicotine-based products in this country, in particular the juice used in PVs, is illegal. So each person who is using nicotine in their liquids is making a conscious decision to import it for their personal use. To assume that every PV user has

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Mailbag: continued

nicotine in their liquid is just another example of how poorly you let your hatred for smokers in general guide you whilst writing this article.

Why are the cigarette manufacturers getting interested? It is purely because they see a money-making venture. If people stop smoking cigarettes, they don't make money. No doubt the government will back this scheme, imposing taxes on PVs and their juices just as they do with cigarettes, in their failed attempt to stop people smoking. Clearly, the health of this country's citizens comes second to the government's need for money, otherwise they would be banned altogether.

On what basis can you say they are just as harmful as tobacco-based products? Is it not OK to have removed the 4000 other toxic chemicals that were formally inhaled daily?

Next time you cross paths with a smoke machine, remind yourself that you are breathing in the same "toxic vapour" that is emitted from a personal vapouriser – vegetable glycerine. This is clearly a highly toxic substance that every child breathes in at the local school disco. Now now, we can't have that, can we? Will next month's editorial be based on the dangers of fog machines?

Further, you may note the secondhand vapour effects. The same vapour that is in fog machines. In the concentrations used in a personal vapouriser, it dissipates within seconds.

Comparing personal vapourisers to LSD – on what grounds can you make such a horrendous claim? A hallucinogenic drug and a chemical free personal vaporiser!

And you make a pretty poor recommendation to schizophrenic patients. I suppose, due to the toxicity of the vegetable glycerine in the juice, it would be severely detrimental to their condition wouldn't it? And adding nicotine to the mix, which is medically approved for these patients as a treatment would be more of a farce would it?

I would like to have cited your sources when you say they offer no benefit in quitting smoking. Once again your closed-mindedness has failed to let you step off your soapbox and delve into the truth. I can put you in touch with thousands of ex-smokers, who all quit with the assistance of a personal vapouriser. In instances where every other NRT product failed for them, and often gave them serious side effects. I have direct family members, who after 30 years of trying to quit cigarettes, are now finally smoke free; some with the use of nicotine, some without.

I should also mention the numerous white papers produced on the key benefits of nicotine in a wide range of medical areas. These studies outline how nicotine can be used in a number of ways to treat a number of ailments, despite its toxicity. If you did any research into the topic, you too would be aware of these. Then again, you would call it all lies and rubbish, because you have formed a personal opinion and won't step aside from that.

I am pretty certain this will not be the only response to this editorial and I would never expect mine to be published but what's the bet that not a single letter regarding this edi-

torial, unless in complete agreement with the editorial, will be published?

Nash Kovacevic
Highett, Vic.

Comment: the glycerin or glycol used in fog machines has low toxicity. Nicotine is highly toxic. Nor does there appear to be widespread medical endorsement that personal vapourisers are a safe or effective nicotine replacement therapy.

E-cigarettes less harmful than conventional cigarettes

The Publisher's Letter on E-cigarettes concerns me. The argument that because cigarette companies want to get into that market means it is BAD is irrational. Should big business get to make E-cigarettes, you would expect regulation unlike the status quo (where the fluid supplied may not even contain nicotine).

Ten (10) current E-cigarettes would have to be smoked in a confined area to create the same nicotine level in passive smokers that one (1) normal cigarette does. There is no toluene or heavy tars that contribute to pulmonary disease. However, heavy metals are released, much the same as from a soldering station. This needs regulating.

All chemicals are potential poisons. Toxicity depends on use, education and regulation. Nicotine can be used therapeutically and comparing its capacity to poison with strychnine and arsenic is inappropriate. Paracetemol is readily available, unregulated in its supply, and more than eight (8) tablets (4 grams) in 24 hours can cause liver failure in an adult.

As a non-smoker, allergic to cigarette smoke, E-cigarette smoking is less offensive to me. The toxicity to the smoker may have to be further clarified but for now, user beware.

Henry Berenson,
Macgregor, ACT.

Comment: E-cigarettes are presently being marketed on the basis that they are less harmful than conventional cigarettes, which is true. However, once they are made and heavily promoted by the major tobacco companies, it could easily give the impression that they can be smoked with impunity. But

Obtaining a car radio for the Mini Entertainment Centre

With respect to the Mini Entertainment Centre presented in the February 2014 issue, I have been in contact with my nearest JB Hi-Fi store who advise that the $70 AM/FM radio was a super-special funded by Sony. The price now remains at $148.

The salesman suggests that I keep an eye on their website for future specials. I'm not interested as this means scrolling through 60+ pages in the "car" category. Could I suggest that you print an explanation in the next issue?

David Voight, VK3FDV,
Kirwans Bridge, Vic.

Comment: it's quite easy. As soon as your email arrived, we found the day's specials from JB Hi-Fi at www.jbhifi.com.au/car-sound-gps-navigation/mp3-cd-tuners/

This showed a choice of suitable CD tuners as they are called, from Sony, Pioneer and Kenwood, all under $90, including the Sony model suggested in the article, at $74.

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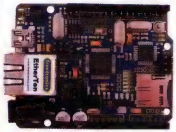
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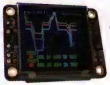
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Mailbag: continued

Signal booster for mobile phones

With respect to the answer on signal boosters for mobile phones (Ask Silicon Chip, February 2014, page 99), there is an inexpensive way to boost signal for some small devices like mobile phones and WLAN base stations. It is the corner reflector antenna. The internal antenna of the gadget is used instead of where the dipole would be in a typical corner reflector. The reflector itself is a V-shaped thin copper or aluminium plate or aluminium bars. It needs to be fairly even, like copper-clad PCB material or aluminium foil with good backing.

A 60° V-corner seems to give the best gain. There are several good web pages with building instructions, like www.qsl.net/ve3rgw/corner.html

Both sides are 430 x 250mm for 880MHz. The distance(s) of the phone from the corner needs to be found by experimenting, starting at about 160mm. The structure supporting the phone needs to be of light wood or plastic. The corner reflector is relatively wide bandwidth and it needs to be, because the receiving and transmitting frequencies are about 40MHz apart. I have not tried it but this arrangement should give over 10dB gain for receiving and transmitting.

The open side of the V-shape must point to the base station within ±10° accuracy, with open space as much as possible in front of the antenna (ie, line-of-sight transmission). It is better to use the phone hands-free, because the reflector also reflects sound away. Some tablets and smart phones have odd-shaped internal antennas, which makes it difficult to focus within a corner reflector. In some cases the reflector may cause internal mismatch, which may lower the transmitter power.

Sakari Mattila, Canberra, ACT.

that is clearly not the case. Overseas, there is rising incidence of nicotine poisoning among E-cigarette smokers.

Solution to poor mobile phone reception

The February 2014 issue had a question from someone who has a problem with phone reception. We are in a known phone black spot, with telephone lines that Telstra has admitted can't handle data and very patchy mobile communications.

Every month or so, I am on-call for work, so I need to be contacted by various people and due to the crook reception, I have to stand on the veranda of the house to receive or make telephone calls. That is somewhat inconvenient.

My Blackberry didn't have an aerial socket, so an external antenna wasn't an option. If the phone was placed on the bedside table at just the right angle, I could receive texts and emails and even though the phone would ring, calls wouldn't hold up, so I would just walk outside to take them. Again, inconvenient but workable.

Then along came some new phones – Apple iPhone 4s for all. Suddenly there was no phone reception at all inside, no data or emails and the Apple also had no external aerial socket. An iPhone 5 was tried but still didn't work. Then I tried an iPhone 5C and it was marginal at best. During all this, we signed up to Telstra Bigpond wireless for internet at home and to give Telstra their due, they have got their act together over the last few years.

We opted for a 6.5dBi gain Omni aerial, which I mounted two metres above the roof line and it worked – 4/5 bars of signal and enough speed to watch movies on line. There had to be a way of getting mobile reception inside, so Telstra was approached and a phone repeater unit, called a "Smart Antenna" was purchased.

The instructions were woeful (one page with some diagrams) but with a little experimenting, it works very well. The system consists of two parts, the window unit and the coverage unit. The window unit is designed to mount beside a window and pick up the mobile signal, which is relayed to the coverage unit placed some distance

away. How far you ask?

Some tests were carried out and it would seem that up to 100 metres line of sight is usable. This means that one unit will cover a sizeable workshop and yard area, with mobile coverage extending in excess of 200 metres in the open; not a bad improvement.

The window unit was mounted in the garage and has an external aerial socket. This was connected to a small Yagi aerial. An adapter will be needed to connect an external aerial to the box and you will probably need to loosen the nut on the socket to allow enough "wriggle room" to screw the adapter in. The coverage unit was placed on top of the fridge inside.

Here the instructions are vague. I found that the best thing to do was to get the maximum signal into the window unit possible, as indicated by the number of green LEDs that light up on the front of the box. Then try different mounting places for the coverage unit to get the highest number on its display. Aim for 8 or 9 but in practice 2 or 3 will work.

How many phones will it operate at once ? No mention is made of this in the instruction sheet but we have had four operating at once without trouble. The data side of the repeater box isn't as good, as when accessing the internet from a smart phone, the speed isn't blinding as would be suggested from the signal strengths indicated. It still works adequately though and enables the sending and receiving of emails and so on.

The price is around $800 from Telstra. And yes it is approved, so there is no danger of getting pinged for using an unapproved device.

Peter Laughton,
Tabulam, NSW. SC

Valve radio could be popular project

I've just finished building my first valve radio and it's turned out pretty well. The idea came from The Radio Board website over in the US but some of the extra info came from an old article by Rodney Champness at http://archive.siliconchip.com.au/cms/A_101592/article.html

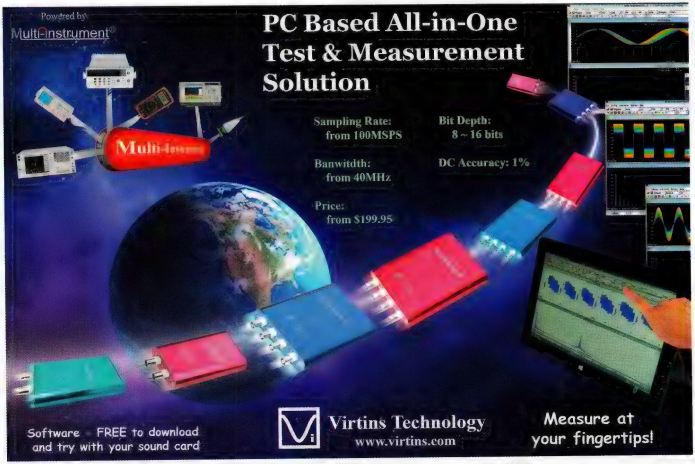
I haven't quite finished tidying up the wiring yet but it works really well and I'm wondering about maybe the magazine revisiting that idea. Jaycar does sell several valves and the 8-pin and 9-pin valve sockets. 7-pin valve sockets and some very nice silver mica caps etc can be bought cheaply from EVATCO by mail order, so those parts are gettable.

Tuner caps (365pF) can be ordered overseas from MTM Scientific in the US at www.mtmscientific.com/capacitor.html I've dealt with them several times before and they always give you what you pay for and it comes in just over a week.

The Xtal Set Society also supplies metallised tuner caps and other basic parts such as Fahnstock clips. See www.midnightscience.com/catalog5.html#part2

So there are suppliers who can provide all of the parts necessary for such a project.

Austin Hellier,
Brisbane, Qld.



Digital Cameras Come of Age

For many people, especially those under 20 years of age, a digital camera has been the only way to take a photo. Compared with the 188-year history of photography, the rapid progress of digital cameras has been truly been remarkable and one can only wonder, now, how we put up with the hassles and horrors of silver halide photography.

by Barrie Smith

The first digital camera, developed by Steven Sasson (pictured) and Gareth Lloyd of Kodak was used to take a B&W image of Kodak lab technician Joy Marshall in December 1975. It weighed 4kg, took a 100 x 100 pixel image and took 23 seconds to write the image to cassette (top right) – and the same time to read it back!

I'd been writing about cameras of the film variety for years, then began to delve into digital cameras specifically about 20 years ago. So the original title of this story was 20 Years of Digital Photography. Oops!

In scraping only the top few layers of dust off my files I began to realise my early involvement with pixel pictures went back a good deal further than 20 years.

But then I woke up to the fact that digital photography far preceded my own involvement and level of curiosity.

Where did it start?

According to Wikipedia, the first digital image was produced in 1920 by the "Bartlane" cable picture transmission system, a method developed by British inventors, Harry G. Bartholomew and Maynard D. McFarlane.

The process consisted of 'a series of negatives on zinc places that were exposed for varying lengths of time, thus producing varying densities.' The Bartlane cable picture transmission system generated at both its transmitter and its receiver end a punched data card or tape that was recreated as an image.

1951 saw the first video images recorded to magnetic tape, as analog signals. By 1956 Ampex had launched the revolutionary video tape recorder (VTR) and the American public saw the first TV program rebroadcast from tape on November 30, 1956.

The first flyby spacecraft image of Mars was taken from Mariner 4 on July 15, 1965 with a camera system that used a video camera tube whose images were processed by a digitiser, rather than a mosaic of solid-state sensor elements. We cannot strictly call it a digital camera but it did produce a digital image that was stored on tape, for later slow transmission back to earth. NASA also used computers to enhance these images.

Texas Instruments patented a film-less electronic camera in 1972 — a first. However it was the invention of the charge-coupled device, or CCD, in 1969 that really propelled the digital capture and storage of photographic images. In 1973 Fairchild Instruments delivered the first commercial capture opportunity with a 100 x 100 pixel CCD earlier developed by Bell Labs.

This was taken up by Steven Sasson, an electrical engineer at Kodak who, with associate Gareth A Lloyd, produced the first working digital camera in 1975. The device used an analog-to-digital converter 'stolen from a digital voltmeter

The 1981 Sony Mavica, the first commercially available electronic still camera – actually a video camera that took 570 x 490 pixel freeze-frames.

The Dycam was the first totally integrated computer-oriented point and shoot digital camera to arrive in Australia.

application' plus a Kodak Super-8 movie camera lens. The digital data was recorded onto a portable digital cassette instrumentation recorder.

Taking its first picture (in B&W) December 1975, Sasson's camera weighed nearly four kilograms and carried only 0.01 million pixels of memory leading to a 100 x 100 pixel image. This image took 23 seconds to record onto the cassette and another 23 seconds to read off a playback unit onto a TV.

At the time Sasson predicted that digital cameras would be viable in 15-20 years. Good guess: Kodak launched its first commercially available camera in 1994 — 19 years after Steve's invention.

A video interview with Steven Sasson is well worth watching. Go to www.youtube.com/watch?v=wfnpVRiiwnM

In 1981 Sony released the Sony Mavica electronic still camera — the first commercial electronic camera. Images were recorded onto a mini disc and then placed in a video reader connected to a TV monitor or colour printer. Even though it started the digital camera revolution, this early Mavica is not a true digital camera. It was a video camera that took video 570x490 pixel freeze-frames.

By 1986 Kodak scientists had invented the world's first sensor capable of recording 1.4 million pixels. It could produce a 12.5x17.5cm digital photo-quality print. In 1987, Kodak released seven products for recording, storing, manipulating, transmitting and printing electronic still video images. 1991 saw Kodak release the first professional digital camera system – the DCS100, built from a basic Nikon F3 SLR camera body and a 1.3MP Kodak CCD camera back.

Dycam

In early 1992, I had a close look at the unusual Dycam (aka Logitech Fotoman), which I described as the 'first totally integrated (hardware and software) computer oriented "point and shoot" digital camera to arrive in Australia.'

Neither still, nor video camera, hand-shaped and a using a hybrid of both technologies, it looked like neither. It took 320 x 240 pixel B&W images (PICT or TIFF), 32 of which would fill the camera's 7.5MB of DRAM. The 8mm lens was fixed focus, imaging to a 1/3rd inch CCD packed with 90,240 pixels.

The first Apple QuickTake 100 camera was fitted with an f/2.8, 8mm lens and could take eight 640x480 images.

The 32 images would remain in memory, without a battery recharge, for about one day!

One oddity: because the CCD captured the images with off-square pixels it was necessary to rescale the pictures by increasing the vertical proportion by 18%. Price: $1705.

QuickTake

The arrival of Apple's binocular-shaped QuickTake 100 camera (built by Kodak) in May 1994, was a landmark. At the time of my review I described it as having 'some pluses and some minuses: no film to load, no wait for processing and — if your images are to end up inside a computer — no scanning . . . On the minus side, the camera had a maximum capacity of eight shots (at top resolution), no focus or exposure controls and possesses the most rudimentary flash system.

But it did have an internal flash!

If you're curious, the manual can still be downloaded from http://manuals.info.apple.com/MANUALS/0/MA690/en_US/0306161AQT100UG.pdf

The first QuickTake, model 100, was fitted with an f2.8/8mm lens, equivalent to 50mm in 35mm SLR-speak. It could take eight 640x480 images, written to one megabyte of EPROM flash memory in the camera's QuickTake format, then externally converted to PICT or TIFF format. No space saving format such as JPEG in those days! Cost: A$995.

The Casio QV-10, released in 1995, was the first digital camera with a built in LCD monitor, and is credited with at least kick-starting the whole digital camera revolution.

My comment on the picture quality of this camera was: 'Colour quality ... surprisingly good, well saturated and, provided your exposure was within the ball park, a little judicial fiddling with Photoshop ... could reward you with excellent results.'

This was followed a few months later by the Kodak DC40 in 1995, the Casio QV-10 (first with an LCD screen), and Sony's first Cyber-Shot camera in 1996.

Retail stationery company Kinkos and Microsoft both collaborated with Kodak to create digital image-making software workstations and kiosks which allowed customers to produce CDs and prints. Hewlett-Packard was the first company to make colour inkjet printers that handled the output of digital images.

While Kinkos has gone the way of the dodo, surprisingly these retail printing outlets are still extremely popular at outlets such as Officeworks and Big W as mums and dads sit at the easy to use workstations and pump out 10x15cm prints at 9 and 15 cents respectively. Perhaps this popularity is not so surprising when you compare the alternative to printing your 10x15cm snaps as printer manufacturers such as HP, Canon and Epson continue with their rapacious pricing policies of ink cartridges, let alone the cost of self-

Above: Kodak's DC40, released in 1995, while at right is a more recent Kodak camera from 2003, the EasyShare DX6490, with the (then) enormous zoom range of 10x.

purchased printing paper.

Progress

At this point digital cameras were still relatively primitive.

What was needed for the technology to really take off was an increase in resolution, a rise in image quality, smarter and faster internal processing, more sophisticated storage methods, better lenses with a longer zoom range. All of this happened over the next decade and we're still progressing.

From this distance it is truly amazing that the early digicams, such as the first QuickTake and the Dycam 1 caused so much excitement, especially if you consider their image resolution as measured in pixels.

The usual rule-of-thumb to determine final print dimensions is to divide an image's resolution by 300 (inches) or 118 (cms). So, the QuickTake's 640x480 pixel images could produce a print 2.13 x 1.6 inches or 5.42 x 4.1cm in size. In recent years, with a 'decent' quality digital image, the 300/118 factor has been found to be 'stretchable' to 200/79 (inches/cms)

My first printer capable of working with digital images was a C Itoh ImageWriter dot matrix model, marketed by Apple. It weighed a ton, cost a motza and produced atrocious prints. This printer was better suited to text output and even then its quality compared badly to today's inkjet models, which appeared in the 1980s and made by such companies as Canon, Epson, HP and Lexmark.

Today, the quality of 21st century prints made by photo quality printers — both inkjet and dye sublimation methods as well as some colour laser printers — is truly remarkable and easily rivals the best made by traditional photographic methods.

In camera sensors, today's digital cameras use a CCD or (increasingly) a CMOS image sensor.

CCD and CMOS sensors convert light into electrons. While there are numerous differences between the two sensors, they both read the value of each cell, or pixel, in the image. The more pixels in the sensor, the more detail it can capture and deliver larger output in the way of an acceptable print. Or so you would think: in recent years consumers have been persuaded to assess comparable digicams by comparing the

Canon's PowerShot SX50 HS has an exceptional wide/telephoto zoom, as seen below.

megapixel count of each.

But those clever camera makers have shrunk the size of each pixel, so now a $200 camera can have a sensor with the same pixel count as a $2000 digital SLR (DSLR) ... but the latter's sensor will be larger, so the pixels are larger and less likely to produce artefacts such as noise.

Another difference between sensors is dynamic range with (naturally) less expensive cameras usually delivering lower range.

Early cameras relied on limited internal memory but, as demand for increased resolution rose, so did the need for a better method of storage.

Enter the flash memory card

To my mind this is an incredibly clever device which first saw application in digital photography in the form of the CompactFlash card, quickly followed by SmartMedia (both of which are now largely superseded), Sony's Memory Stick (in all its variations) and most recently the MultiMedia Card and SD card (and variations). In most cases, the MMC

Canon's recent PowerShot SX50 HS with a 50x zoom has a 35 SLR equivalent of 24mm to 1200mm in range. These views of Narrabeen Lagoon demonstrate its capabilities – the telephoto shot on the right is of the area marked by the red rectangle on the wide-angle shot at left. Can't see it? Look closer! You needed to bear in mind that, as the manual states, 'using the tele end of the zoom will see you face off atmospheric haze.'

This to scale (but not to size) image shows the evolution of flash cards over the years. The CompactFlash and SmartMedia cards (at left) have been largely superseded; even the still very popular SD (and MMC) cards have given way to very much smaller SD variants, driven by their popularity in mobile phones and tablets. The tall blue card is the original Sony MemoryStick; it too has been largely replaced by Sony's Memory Stick PRO Duo and M2. At right is Fuji's proprietary XD card which proved quite unpopular as (like the Sony) it fitted little else and most computers didn't sport XD card readers.

and SD cards are interchangeable if they are of the same physical format. Incidentally, some incantations of SD cards especially have different names, dependent on the manufacturer – for example SD and T cards.

Aside from Sony with its proprietary Memory Stick cards, two companies (Fujifilm and Olympus), saw a market opportunity and launched the xD-Picture Card, usable by only these company's cameras. By 2010 the card was obsolete due to its inability to match the write/read speed of CompactFlash and SD cards as well as the enormous takeup of the latter (especially the miniature versions) by mobile phones.

The market battle at the consumer level today is between cameras offering not only high 'pixel populations' but also extensive zoom specifications.

I well remember an early Kodak camera, the EasyShare DX6490, which had (to me) the enormous zoom range of 10x and sold for $1099. Called 'maxi zooms', these digicams with enormous zooms had enormous appeal and the category was topped by Canon's PowerShot SX50 HS that boasted a 50x zoom that ran from a 35 SLR equivalent of 24mm to 1200mm in range. I say 'was' because news has just come through that Panasonic now have a Lumix DMC-FZ70 with 60x zoom and a 16 megapixel sensor!

But all is not rosy in maxi zooms of this range: move from the maximum wide angle to the tele end and the maximum aperture of f2.8 quickly shrinks to f6.3! That's fine for brightly-lit (ie, sunny!) scenes but not good indoors or at night.

My review of the Canon camera at the time pointed out that, while the image quality was 'above average', you needed to bear in mind that, 'using the tele end of the zoom will see you face off atmospheric haze. The shot of the bridge shot at full tele and shown here was 1.8km away.

To use it: 'hard to deal with, you need some patience, a decent tripod and suitable subject matter to use it satisfactorily ... if you plan to do any amount of long lens shooting, go get yourself a decent tripod; try out the camera in the store before you buy and avoid wobbly legs!'

My full review is at: **http://digital-photography-school.com/canon-powershot-sx50-hs-review**

Today most cameras will capture and write image files in JPG (usually referred to as JPEG) or RAW formats. With JPEG it's a balancing act between compression, faster memory capacity ... and of course, image size: at the highest compression level the image size in bytes can often be reduced dramatically.

A compression factor of 10:1 can often have little effect on the picture quality. An image of minimal detail will compress to a smaller file in bytes than an identically sized image of maximum detail.

For example, images with large areas of sky will suffer less and compress to a smaller size in megabytes. A crowd of faces will tolerate less compression and lead to a larger file size.

JPEG is also unsuited to multiple edits and saves – some image quality will usually be lost each time a picture is decompressed and recompressed. A rule-of-thumb is 5-10% each time. The ideal approach is to save the 'master' JPEG immediately after it is downloaded from the camera and

Top level DSLRs like Canon's EOS Mark 5 III, Sony NEX-7 and Nikon's D4 model are used in TV drama and feature film production to capture the action that ends up on the giant movie screen.

Facing off the DSLRs in movie work are the more traditional, purpose-designed video camera/recorders such as the Arri Alexa.

Sony's NEX-3NL "prosumer" 16MP camera – as small and light as a point-n-shoot but with interchangeable lenses – said to have the best image quality of any compact camera.

work with copies for subsequent image processing.

The RAW format is increasingly seen on even mid-range fixed lens digicams and is regarded by many experts as the ideal way to deal with digital camera images, as a RAW image is written to memory from minimally processed data transferred from the image sensor. However, unprocessed these files are not printable nor editable with most software.

RAW images need to be converted to other formats (TIFF, JPEG etc) to undergo subsequent transformation or output. Some cameras, such as those made by Nikon, Sony and others use a proprietary format and may require translation to a Photoshop-readable RAW format.

JPEG/RAW Pros and Cons

JPEG files are smaller (often significantly so); they usually have sufficient quality for most purposes; they're quicker to shoot (camera processing is quicker). A JPEG image is 8-bit (256 brightness levels).

RAW files holds the maximum amount of data about the image, later retrievable; white balance has not been set and can be determined later; most RAW files are captured with 16-bit information (65,536 brightness levels.

DSLR vs Compact

Another question that faces the amateur with ambitions to make an impression on the photographic world: is the DSLR the better way to go?

I frequently like to quote my maxim: it's the driver, not the car!

An extreme comparison is to see fabulous images captured by a top pro with a consumer level, fixed lens camera, while over on the other side of the picture you will see, very frequently, really poor images taken by a raw amateur, using a DSLR and top quality lens package whose total purchase price could easily have bought a small Asian sedan!

These days, "consumer level" cameras are impressive and some models have impressive specs – far more than the average user will need in most circumstances. But if you're really serious about digital photography (and you know your stuff!) nothing beats a professional model. And don't forget, between the two extremes there really are some outstanding buys around – quite high spec models at prices we could only dream about just a few years ago. Why pay more than you need to?

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Nostalgic Radio is back!

Retro Rou

Enjoy Golden Oldies with modern reliability

Retro radios have that style reminiscent of bygone days when we enjoyed the family "wireless" in the kitchen or loungeroom. Now we can enjoy the bygone features knowing the new radio has a warranty and should last for years. Modern retro receivers vary in size, case design, sound fidelity and build quality, so this comparison is a guide. The sound quality is not hi-fi but most listeners are happy to relax with the news, talkback or old tunes reproduced in a "mellow" tone.

Seven "retro" radios are reviewed in detail here and to remind us there's still life in some vintage radios, a few old-timers are mentioned.

Perhaps the ideal for a true vintage-look radio for daily use is to take the approach used in the Mini Entertainment Centre (last month) but use an old-style cabinet.

However, the D-I-Y approach may well miss out on the latest developments, such as DAB+, unless you use a radio receiver offering this facility.

Even manufacturers of some "retro" sets seem reluctant to include DAB+, probably because of increased cost.

All the ratings in the comparison chart are largely subjective. In most cases the tiny loudspeakers being used immediately limit the possible sound quality and volume.

Most of these radios were purchased; only a few were provided as review samples.

DAB+

Where available (and that's increasing all the time) Digital Radio (DAB+) reception is certainly noise-free but in many cases, the sound appears to lack tone in the small loudspeakers, compared to that from the FM stations.

Retro Radios, Mantels and Portables

Brand	Model	AM	SW	DAB+	AC or DC	Audio in	Audio out	Audio Output	Volume Level	Audio Quality	Tone Control	Retro Rating	Overall Rating	Street Price
Bush	TR82	✓	(LW)	✓	AC/DC	-	Line	2W	8	7	✓	10	9	$90
Tesslor	R601	✓	-	-	AC	RCA	Line	4-5 W	9	8	-	10	6	$195
Crosley	Ranchero	✓	-	-	AC	3.5mm	-	1W	8	7	-	9	7	$99
Roberts	Revival	-	-	✓	AC/DC	AUX	Line	1W	7	7	-	9	8	$279
MagicBox	Astor	-	-	✓	AC/DC	-	-	.7W	6	6	-	8	7	$89
Nostalgic	CR-065	✓	✓	-	AC	L/R	line L/R	3+3W	9	6	-	8	7	$199
Bush	Heritage	-	-	✓	AC	AUX	-	10+10W	10	10	7x EQ!	8	10	$246
Not tested but worth considering														
Roberts	Vintage	-	-	✓	AC/DC*	3.5mm	Line	1W	**	**	-	8	**	$229
AVES	Classic	-	-	✓	AC/DC	-	-	2.5W	**	**	-	7	**	$99
AVES	Tango	-	-	✓	AC/DC	-	-	2.5+2.5W	**	**	-	7	**	$129

Notes!!

1 The highlighted Bush Heritage features contributed to the highest rating. This was the only radio that replayed DAB+ in with good sound.
2 The audio quality compares "apples with apples" and not to much larger hi-fi systems.
3 Prices are the best average at the time of printing. Some radios are occasionally on special up to $100 cheaper. Example: we purchased the Heritage at $179.
4 The Tesslor will get a score of 9 or 10 when technical issues are solved. An earlier model was finished in very attractive high-gloss.
5 The MagicBox is a great lightweight fun portable and the only small radio reviewed here.
6 The Nostalgic Radio would be better without the CD player, as it may not last, plus wiring standards could be improved. It would be good to try quality speakers too.
7 * Roberts Vintage model will operate on AC, alkaline or rechargeable batteries.
8 ** Not tested.

ndup

By Kevin Poulter

This quick reference table shows all models included in this mini-survey. All offer FM reception but less than half have AM and only seven offer DAB+. Only the Bush TR82 has all three – with LW thrown in for good measure (not really usable in Australia!). None have provision for an external speaker, although all include a 3.5mm headphone socket. About half have a line output socket, which could also be used to drive an external amplifier and speakers for significantly improved sound. Individual reviews of each of these (except for the last three) begin overleaf.
You'll find more detailed information, suppliers links, DAB+ information, etc, at www.aaa1.biz/SC/retro.html

AM reception should always be included in receivers, to cover areas where DAB+ cannot be received. Sadly, as our comparison chart shows, AM is fitted to only about half the retro radios in the survey.

CD Players

Some of the units have CD players. Personally, I have major reservations about these, as it has been my experience that CD players in low-cost equipment often fail prematurely and then typically cannot be repaired. While many readers may not agree with me, I cannot see the point in including a CD player in a "retro" radio and believe they would be better off without them.

Vintage

Many readers prefer the "real thing" and would prefer to restore vintage radios, usually of the valve genre.

Typical valve radios had a larger speaker and the overall sound quality, particularly in the bass, is better. This applies more to console sets than mantel radios.

In preparing this article, we compared retro radios to some larger portable vintage radios. Some had more full-bodied sound, like the ghetto-blaster below, however none were even close to the sound quality and features of the Bush Heritage. However, because of the low prices asked for these, they may well be a better option than a "retro."

Post-60s solid state radios are an option too. All these were available at $50 or less at HRSA (Historical Radio Society of Australia) sales or Op Shops. The near mint-condition Ghetto-Blaster on the right came from an Op Shop for just $15.

Crosley CR3022A Ranchero

The Crosley Ranchero AM/FM radio (above) looks like an old-style car radio installed in a mantel radio cabinet. The Australian model is only available in black and the USA version only available in red. Compare this to the original 1950s "PYE" set (AM only) shown below and you can see where the styling ideas came from. Other brands offered similar designs.

1950s "PYE" set (AM only).

Styled like a number of brands in the 50s including the Australian PYE, this design is reminiscent of a car radio installed in a mantel case. The receiver is AM/FM with a MDF case in superb glossy black piano-finish. In USA red is the only choice on the Crosley website.

With clean, compact lines, the authentic look is retained by placing the AM/FM/Aux-in switch on the back panel. A minor point, the raised "pointer" on the function knob did not line up with the function it was set on.

The FM wire aerial needed fully extending in our metro area, it then received a wide range of stations well. Sound quality is good compared to others and if you like the style, it will look appealing on the shelf.

MP3 players and the like can be connected via a 3.5mm input socket and a headphone socket is provided. Typical of all the sets in this roundup, sound quality using a good pair of headphones is significantly better than using the tiny internal speakers.

Size: 333 x 180 x 135mm (w x d x h)
Pros: Good design and sound, external aerial socket.
Cons: None.
Source: iWorld (see links at finish of this article)
Price: $99.95
Overall Rating: 8 out of 10

Nostalgic Music System, Model CR-065

The Nostalgic Radio is very similar to European Philips and other euro brands in the early 1950s. Built in a timber case, it's larger than all other mantel radios in this roundup. Features include AM/FM with two shortwave bands, CD player, MP3/USB port and SD/MMC card port.

The biggest unit by far, it has two speakers in a larger "speaker box" for more full-bodied sound and in stereo, to boot. There's no brand on this unit; the title comes from the instruction book.

On opening the well-packed radio I found the CD player was not working. The supplier said this was highly unusual and rather than paying expensive freight to return it, he offered a discount.

The CD mechanism is direct drive, with no belt, so the fault could range from an open circuit motor to the electronics or connections. Regardless, I won't miss a lower quality CD player that's bound to have a short operating life, like many a CD player in small systems.

On this set, you need to use the controls gently, as they are not rugged. The outer rings of the main knobs are not tone or other

Maybe the Nostalgic is a little *too* retro: it certainly doesn't follow modern wiring techniques! For example, the yellow LT AC wires are not twisted, the white FM wire easily drapes over 240VAC power leads and the full-wave rectifier diodes are close to audio circuits. The speaker leads are also not twisted or clipped to a specific path and the speakers are unlabelled.

function, just decorative and the large volume knob is mounted on a very small pot. Also,the piano-key switches are connected via levers to light-duty switches.

The Chinese English in the manual is 'different', however you get the gist of it. For example "Do not wet hands touch the power cord." "During to use CD/USB/SD card, the occasional silly machine or confusion..." "to save power and security, for a long time do not use this product, please ensure that the full power interruption." The latter translates to: "If you are not using the unit for a while, disconnect it from the mains, as only the low voltage DC is switched." My advice is to use a switched power board and always turn off the mains after use. It also mentions a cassette player, which the unit does not have.

Designed by new-generation technicians who were not exposed to tried and proven techniques, the quality, wiring and placement of circuit boards could be improved. For example, the FM antenna wire drapes over the mains leads or power transformer and the transformer secondary power leads are not twisted, while the bridge rectifier is close to the audio section.

However the radio is an interesting mantel and if you like the appearance, it may suit you. FM reception is improved by extending the telescopic aerial on the back panel and the FM tuning has a feature where the dial illumination changes to blue when tuned to a station. After reading a USB or SD card with MP3 music, the controls resemble a CD player, with fast forward, program, repeat and more. "AUX in" will suit many portable music devices and there's also 3.5mm line out and headphone out sockets.

Size: 510 x 290 x 340mm (w x d x h)
Pros: Large cabinet enables two speakers and big sound. Many features.
Cons: Electronics could be better built. The piano-keys and volume control are not durable
Source: ebay - warehouse_seventeen, or direct - see our links page.
Price: About $200
Overall Rating: 7 out of 10

Roberts Revival DAB+/FM radios are available in red or the rarer cream colour below. Beautifully made, this equates to a little heavy – and more expensive ($279 RRP). The gold-plated telescopic aerial is the best-looking you will ever see. If you like the style and don't need AM, Roberts is highly recommended.

Roberts Revival Model RD-60, DAB+/FM

"Feel the quality" is a term that fits well with this medium-size portable. It looks good, styled closely to an early 1960s transistor radio but with modern DAB+ and FM.

If you like the distinction of magnificently crafted 'retro leather' covering over a styled MDF case, with gold highlights and even a gold-plated telescopic aerial, this radio should be on your wish-list. Unfortunately there's no AM.

Now claimed to have 120 hours of battery life on 4 x D size cells, this radio comes in red and cream (limited stock), though most will choose red. The Revival features rotary tuning and volume controls, RDS station name display, a stereo line out socket, and headphone socket – which delivers excellent sound. Like all portables, DAB+ sound could have more bass and midrange.

The sound output is quoted as 1 watt, which appears correct and unlike others, it does not increase distortion excessively near full volume. Interestingly, the speaker has a plastic port to help improve sound quality. The port seemed to work best when the rear cover was open for battery access!

Other features include: station name / multi preset mode, one-touch instant access to favourite stations, FM RDS station name display, easy-to-read 16 x 2 line LCD readout, amber display backlight, stereo line-in socket for iPod / MP3 playback, stereo line-out, stereo headphone socket, AC adaptor included.

Size: 260 x 130 x 160mm (w x d x h)
Pros: Style, quality, features, stereo line out.
Cons: No AM, fairly expensive.
Source: Harvey Norman, The Good Guys and Retravision.
Price: $279 RRP; $216 at Big W on-line
Overall Rating: 8 out of 10

Also consider: Roberts Vintage
(not tested but similar to the Revival)

The Vintage beautifully blends 'retro leather' cloth finish and wooden effect side panels with modern DAB+/FM technologies. You can enjoy limited station presets and a favourite station button.

Features: up to 80 hours battery life, built-in batter charger – ideal for standard (C size) rechargeable batteries, FM station name display, rotary tuning and volume controls, station name /multi-preset mode, one-touch instant access to favourite station, USB socket for software upgrades, aux-in for iPod / MP3 playback, headphone socket, battery or mains operation via AC adaptor (included)

Pros: Style, quality, features, battery charger built-in.
Cons: No AM, fairly expensive.
Price: $229 RRP; $189 at Appliances on-line (see links for more)
Overall Rating: 8 out of 10

MagicBox "Astor" FM/DAB+

The MagicBox "Astor" FM/DAB+ is amazingly light, with a chrome and pastel appearance. Great for teenagers to older people who like to listen to music or talkback, without needing generous bass or treble.

A fun, lightweight, attractive, colourful portable, great for personal or mobile use, like picnics. Good volume in a very portable radio, with excellent quality on headphones too. A telescopic aerial ensures top reception on FM, plus DAB+ areas.

A host of discreet buttons enable station scan, set favourites, info/menu and the Astor can store your best 9 DAB+ and 9 FM stations. Power choices are four AA cells or the supplied mains plug-pack.

Size: 225 x 680 x 150mm (w x d x h)
Pros: Colourful, fun look, super-lightweight, clear sound, many function buttons.
Cons: None
Source: Selected Harvey Norman stores
Price: $89 RRP
Overall Rating: 8 out of 10

Bush TR82DAB - DAB+/ FM/AM/LW

Bush TR82 AM/FM/MW/DAB+ is a near-identical copy of their 1959 model. Priced about $85-$99, this large lightweight radio has a larger speaker and is great value.

You'll love the style of this near perfect reproduction of the iconic 1959 Bush TR82 transistor radio, with classic style by Ogle Design. This Bush model was reviewed in Silicon Chip, September 2013.

Taller and bigger than most transistor radios, it delivers. The inclusion of AM (MW) is excellent, as many AM stations are top of radio ratings around Australia and DAB+ is not yet received in many areas outside of the capital cities.

Most of all, the price blows away other DAB+ receiver brands with tiny speakers.

DAB+ tuning, plus buttons for presets and the LCD readout are inconspicuous on the top panel. The ten station presets are a great feature, however when used only on mains, they disappear after power is disconnected.

Installing batteries overcomes this, though it would be even better

Too late for the roundup – but worth a look:

Two other contenders came in as we completed the round-up. The Roberts Vintage model is about $229, with built-in battery charger, DAB+ / FM, Aux in for iPod / MP3 playback, battery or mains via the included AC adaptor.

The AVES Classic DAB/FM Radio retails in Australia for $99 RRP. Features include: Alarm, snooze and sleep Timer, 2.5W RMS, AC Adaptor for mains, or 4 x 4C cells.

if the memories were flash type, or if there was a memory battery. The station search resembles "seek" on a car radio and is excellent.

There are so many DAB+ controls and features, reading the handbook on the web is a good idea.

Reception

AM and FM stations are received well. Numerous DAB+ stations can be received in most state capital cities and suburbs, Bush says "if no DAB+ signal is found in your area, ... relocate your radio"!

So be sure DAB+ can be received in your area before purchase, if DAB+ is a major purchase decision.

A great test of DAB+: I tuned an AM station and placed the Bush near a noisy computer power supply, resulting in overwhelming noise and zero AM reception. Switching to the same station in DAB+ produced clean, noise-free sound! Incidentally, DAB+ has a 7 seconds delay compared to the same AM station.

Great sound

Overall the modern Bush sound and tone is better than large transistor radios of bygone days and the best sound of all the portables we tested. Not hi-fi, but pleasant and room-filling volume, with a useful tone control. The headphone out and line-out are also handy features. The fixed level line-out is stereo, via a 3.5mm socket. Tested on a hi-fi system, it performed well, as it did using good headphones via the headphone output.

Case and batteries

The case is sturdy, with a strong handle - very important, as many similar vintage transistor radio handles have broken over the years. Unfortunately thereare no instructions on how to remove the rear cover to install the C size batteries.

The small stickers which give a clue won't stay in place forever and are easily hidden by the handle.

Most would expect to undo the main screw on the rear with a five cent piece, then prise the cover off. However that would damage it. The method is to press hard on the two stickers, whilst pushing toward the base, so the rear cover slides off.

Tip: Use rechargeable batteries, as all batteries leak, despite claims to the contrary, yet we haven't seen a good brand rechargeable battery leak.

It's best to turn off the radio at the mains when not in use, as it has the mains on full-time and the on-off only switches the low voltage. Overall highly recommended.

Features

DAB+/FM/AM/LW, 2 watts RMS output, tone control, LCD display, DAB+ Auto Tune, headphone out, line out, telescopic antenna, Dimensions: 35cm L x 28 H x 10.5cm deep (with aerial).

Size: 360 x 110 x 235mm (w x d x h)
Pros: Style, quality, features, AM included, tone control, outstanding value, line out, 2W RMS.
Cons: Rear cover tricky to remove, the FM aerial retaining clip may break – a common problem in vintage radios too.
Price: $99 - occasionally less.
Overall Rating: 9 out of 10

And the winner is:

Bush Heritage DAB+/FM/ Bluetooth Radio

Bush Heritage mantel model is based on a 1958 radio and packs a punch. Bluetooth is excellent and the Heritage is priced at $269. It's the only radio tested that has excellent tone on DAB+, the EQ tone-settings ensure the sound is far and away better than all others here – clearly the winner in this round-up. The extra features we would like are AM, plus loudspeaker out, then this radio would rock a room even more.

A redesign of the 1958 traditional high-end radio, the Heritage is easily the winner of our line-up for sound quality and features. Brought up to date with Digital Radio and Bluetooth Wireless Audio Streaming, this radio will be a hit with modern-tech /Retro lovers.

High Quality Sound

Bush claims 10 watts RMS stereo, suffice to say the sound is ample for living rooms, with more bass than all other compact radios. The Heritage also qualifies as the only radio tested that has great tone on DAB+.

Features:

Large LCD Display, metal grille with wood finish surround, AC power (only), even the soft rubber feet are a nice touch. DRC (Dynamic Range Control) enables setting compression of stations to eliminate the differences in sound level between radio stations. A stand-out feature is the EQ settings which are absolutely brilliant. The sound is so full of tone, you'll rarely need the EQ though.

The manual is the best and well worth a read, as there are many more features than mentioned here (see our links).

Size: 320 x 150 x 170mm (w x d x h)
Pros: Style, quality, excellent tone, EQ, features, understated looks with easy to use controls,
Cons: quite expensive (but worth it!)
Suggested improvements: Speaker output sockets.
Source: JB Hifi, Dick Smith, Harvey Norman and The Good Guys
Price: $249.
Overall Rating: 10 out of 10

OVERLEAF: A more in-depth look at one of the more unusual receivers in this roundup, a four valve hybrid from Tesslor. For those who love the "valve sound" this may bring back some fond memories. It's strictly AM/FM only (it doesn't offer DAB+) but it does have one throwback from yesteryear: a "magic eye" tuning indicator!

The Tesslor R601 Valve Radio

The only valve retro radio tested, the Tesslor R601 is a hybrid, designed and built in China. Intentionally looking very similar to the AWA Radiolette 500M of 1946-1947, it's in a very sturdy Bakelite-look case.

This impressive exterior is actually very thick moulded MDF, likely to survive at least as long as Bakelite. The radio's solid-state section is the RF/IF circuit. First stages of audio are a 6F2 Triode/Pentode with the pentode acting as the first stage, then two 6P1 valves in the push-pull output, plus a 6E2 magic eye.

Sturdy case

With a true "old-style" look, it's very strong and well finished. It closely resembles a deep burgundy, almost black Bakelite finish. Some owners complain of a strong varnish smell when the new case is heated by the valves, which should diminish in time.

Features

The LED dial lights illuminate brightly, without melting the station-dial, as often happens in vintage radios with hot incandescent globes.

Reception is AM/FM and there's line-in for external audio devices like a turntable (not RIAA corrected but adjusting the tone, or an LC compensation network in series will suffice). Or connect CD and portable music players like iPod via the portable music player's speaker out socket.

One of the best features is the vernier dial tuning, so the tuning knob is geared to rotate further than the main shaft for fine and accurate tuning adjustment.

AM and FM reception with the built-in internal aerials is very good in a suburban location, or add the supplied external aerials for near-DX reception.

Tip: you need to switch the int/ext aerial changeover switch on the rear panel. There's a small amount of frequency drift in the solid-state tuner after a while, possibly due to the internal heat.

Technical

Claimed output is 7W into 4 ohms, however the speaker in the unit tested was 8 ohms. Despite the push-pull output, it appears to be nearer to 4-5W RMS, with more than 10% distortion on higher volumes.

The speaker was stamped 5 watts, which inevitably means 5W peak, so considering the output volume and clarity is highly dependent on the speaker, it would be interesting to try different speakers to find the best match. You could try an L-C negative feedback tool and a dual bass/treble pot would be a great inclusion.

The Tesslor R601 four-valve AM/FM hybrid in an MDF cabinet, stained and varnished to look exactly like Bakelite. Note the AWA-style design and the illuminated tuning dial, superbly illuminated by cool-running LEDs, an outstanding feature. But the cool running is countered by the valves, which heat the radio excessively – the air temperature at the rear vent is 65°C! The magic eye tuning indicator is unfortunately swamped in good signal areas. This year the larger Stereo Tesslor R601S AM/FM Radio with Bluetooth 3.0 streaming should be available.

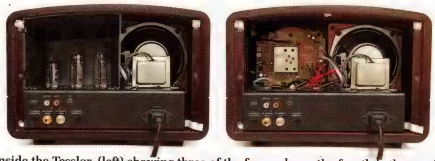
Headphone output

Headphones connect to the rear 3.5mm socket. Fortunately most owners won't use this feature, as the sound has highly suppressed treble – all bass, most likely due to a large resistor in series with the low impedance speaker line. An audio-filtering LC network in series, or a reversed mini speaker transformer would greatly improve headphone performance. Also the radio's output appears to be switched between the speaker and headphones though the small 3.5mm socket contacts, normal in a small radio, but not great for 5 to 7 watts RMS

Size: 300 x 180 x 200mm (w x d x h)
Pros: Nostalgic sturdy AWA style case, well presented mellow sound on old tunes, higher than average receiver performance, excellent dial - bright, clear and cool, vernier tuning, good value, line audio in and out.
Cons: Runs too hot, sibilants, distortion, speaker quality.
Source: Only available on the web www.giftsngadgets.com.au
Price: About $195.00

The Australian price is less than overseas and it arrived well-packed. It was excellent to find the valves held in place with spring-loaded top clips.

Overall Rating: 7 out of 10 SC



Inside the Tesslor, (left) showing three of the four valves - the fourth is the magic eye. Note the valves are surrounded by a plastic "cage" to retain and direct the valve's heat in this small area. The right photo shows the solid-state RF/IF board behind the front tuning dial and the 8 ohm speaker. A quality build.

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Arduino-based GSM Remote Monitoring S

Need to keep an eye on electronic/electrical gear or a power supply in remote locations, such as on a moored boat, holiday house or farm? A loss of mains/solar/wind power or failure of equipment such as pumps could be a disaster – unless you know about it straight away. This unit will send you an SMS as soon as something goes wrong.

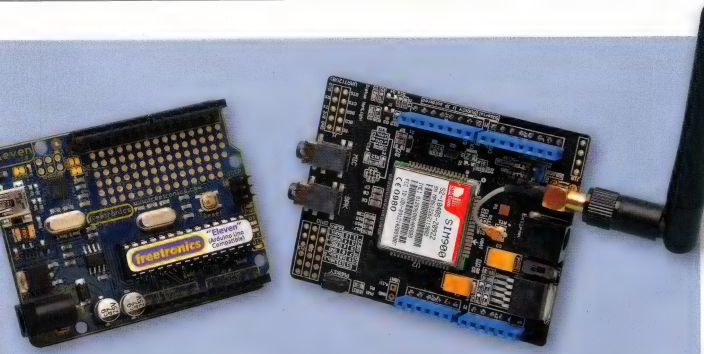
A RECENT INCIDENT illustrates how useful a Remote Monitoring Station like this can be. An acquaintance of one of our staff members has a farm with cattle on it but he's not always around to keep an eye on things. During the Christmas break, a lightning strike took out the mains power back at the pole and so the water pump at the homestead stopped working.

This pump also supplies water to the cattle troughs and they were quickly emptied by the thirsty cattle during the hot weather. Fortunately, a neighbour checks on the property every few days and so the problem was discovered in time, before any cattle were lost. But even so, if he'd had a monitoring unit such as this one, he would have known about the problem almost immediately.

Another good example is for monitoring a boat on a mooring or in a berth. It's common for a boat to rely on shore power or solar panel/wind generator to keep the batteries charged. The batteries are needed to start the motor(s) and also power the bilge pumps which need to be kept operational at all times.

You really need to know straight away if the boat loses power or starts taking on significant quantities of water (as indicated by frequent running of the bilge pumps) and so some form of remote monitoring is very useful. Most boats don't have any sort of permanent phone or internet connection but are generally moored in an area with mobile phone coverage so this project is quite applicable.

And if you have an alarm system



The Remote GPRS Monitor uses a Freetronics Eleven Arduino module (left) and a Seeed Studios Arduino GPRS shield (right). The latter accepts a phone SIM card (on the back) so that it can send and receive SMS messages

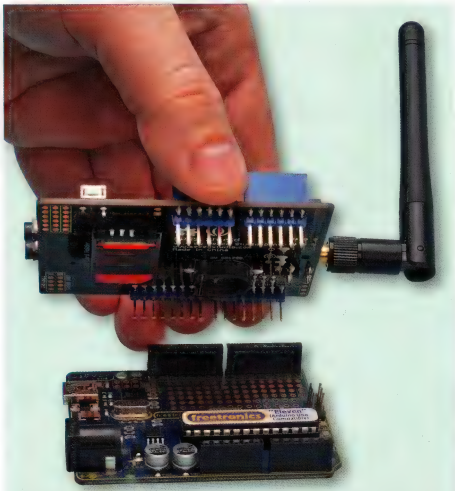
tation

By NICHOLAS VINEN

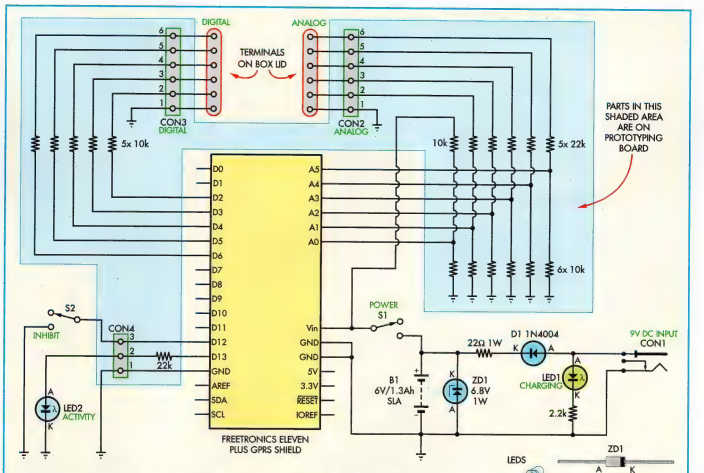
with an output that can indicate when it goes off, this unit can also alert you should your alarm be triggered – whether that alarm is in a house, boat, caravan, etc. In fact you could even wire it up to the ignition system on a vehicle in order to get an alert each time its engine is switched on.

What it does

This unit has five analog inputs and five digital inputs. It constantly monitors the states of those 10 inputs, according to a set of rules that you



Connecting the two modules together is easy – the GPRS shield simply plugs into the Arduino module via the on-board headers on either side. Note that the GPRS shield shown here uses an external antenna but later versions of this module have an onboard antenna.



ARDUINO REMOTE MONITORING STATION

Fig.1: the circuit for the Remote GPRS Monitoring Station. It's based on an Arduino "Eleven" main board (with an ATmega328 microcontroller) and a GPRS add-on module. The extra circuitry shown here includes a battery and simple charger to power the unit, two control switches, two status LEDs and input protection and signal conditioning for the voltages or switches being monitored.

create. If any of the inputs goes into a state which is abnormal, after a preset delay, it will send an SMS to your phone with the state of all the inputs.

It can also be set up to send a periodic SMS too. That way, you can keep an eye on, say, battery voltages even when they are not critical, to get an idea as to whether the battery is being charged properly. And you can also prompt the unit to report to you at any time, by sending an SMS to its phone number. You can also redirect its messages remotely (eg, if your phone's battery has gone flat).

The five analog inputs can monitor voltages in the range of 0-15V with reasonable accuracy – good enough to check the charge state of a lead-acid battery. It's also possible to connect various kinds of analog output sensors but extra interface circuitry may be required, depending on their voltage levels (as explained later). The digital inputs can be driven with a 0V/12V or 0/24V signal or can be connected to switches or relay terminals to track their opening or closing.

Each input can have a separate delay before triggering an alarm, so events which occur periodically can be monitored. For example, you can get an alert if a bilge pump runs more than once every four hours, indicating a larger amount of water ingress than usual. You can also get an alert if a pump (or something else) runs for too long a period.

The Remote Monitoring Station has an internal battery that is kept charged either from mains power via a plugpack or a solar panel, so that a power failure will not cause it to "go silent". It can also be configured to send you an alert if its own battery is running down or if its power source has failed.

The suggested battery powers the unit for about two days without charging but larger batteries can be used. With a solar panel, the unit becomes totally wireless and can be located just about anywhere that there is periodic sunlight and mobile phone coverage.

How it works

Most of the work is done by two prebuilt boards; an Arduino host board which in this case is the Freetronics "Eleven" module and a GPRS (General Packet Radio Service) 'shield' board from Seeed Studios. This shield board allows the unit to send and receive SMS (Short Message Service) messages. You need a SIM card and associated mobile phone number too; a low-cost, pre-paid SIM is suitable but you can also use a 'post-paid' SIM.

The rest of the circuitry is quite simple and consists of a battery, trickle

Main Features

- Monitors up to five analog inputs (0-16V) and up to five digital inputs (0/12V or 0V/24V or open/closed switches).
- Sends an SMS message to a pre-defined phone number upon alert and/or periodic updates.
- Alert conditions can be defined individually for each input, including a time delay.
- SMS messages can be remotely redirected and status updates can be requested.
- Operates from internal battery for 48 hours; can be kept charged from mains or a solar panel.

charger, the analog/digital input interface and some indicator LEDs and control switches. There is no custom PCB as this circuitry is all built on a Freetronics Arduino prototyping shield or uses point-to-point wiring in the case.

Fig.1 shows the circuit. The five digital inputs connect to input pins on the Arduino board via 10kΩ protection resistors. It is therefore safe to apply voltages in the extra-low voltage (ELV) range to these inputs (maximum ±60V). A voltage above 3V will be read as high while below 1.5V, it will read as low. Anything in-between is undefined.

A small pull-up current is sourced from each of these pins just before the state is sampled, so any which are open-circuit will read as high. Thus, you can connect a switch, relay or open-collector/drain device between a digital input and ground. The input will then read high when the switch or transistor is off or low when it is on.

The analog inputs go to the Arduino microcontroller's A1-A5 ADC inputs via 22kΩ/10kΩ resistive dividers. Since the micro runs from a nominal 5V supply, that gives a linear input range of 0-16V. The analog inputs are digitally filtered by repeated sampling and averaging, to reduce noise pick-up.

While voltages above 16V cannot be read by the analog inputs, damage will not occur as long as the applied voltage is within the ELV range (±60V). Analog input pin A0 is connected to monitor the unit's own battery voltage. Since this is a maximum of 7.5V, a different divider is used (10kΩ/10kΩ).

Battery power

The whole thing is powered directly from a 6V sealed lead acid (SLA) battery. The Arduino "Eleven" board has an onboard 5V regulator and this is used to supply power to itself and the GPRS 'shield'. The charging arrangement is very simple, consisting solely of reverse polarity protection diode D1, a 22Ω current-limiting resistor and a 6.8V zener diode to prevent over-charging.

There is also a green LED (LED1) with 2.2kΩ current-limiting resistor connected across the input, to indicate charging. With a 9V DC regulated plugpack, the float charge current is (9V - 0.7V - 6.8V) ÷ 22Ω = 68mA. This gives a dissipation in the 22Ω resistor of 100mW. The charge current (and resistor dissipation) increases if the battery is flat but only to about 150mA/500mW; slightly more if using a 9V solar panel in bright sunlight.

Since the specified battery is 1.3Ah and the circuit draws about 20mA, that means that a full charge will take about 24 hours. Hence this circuit is most applicable to situations where charging power will almost always be present (eg, mains power). It can be used with a solar panel but you may find that a larger battery or better charging arrangement (or both) are required for reliable operation during overcast days.

The rest of the circuitry consists of power switch S1, inhibit switch S2 and activity indicator LED2 with its associated 22kΩ current-limiting resistor. S2 is used to prevent the unit from sending text messages. This is useful during set-up but also if a genuine failure occurs; once you (or somebody else) has arrived to fix the problem it has alerted you to, you can stop it sending more messages by toggling S2. S2 can then be reset once the problem is fixed.

LED2 flashes in various different patterns to indicate what's going on. It flashes periodically and briefly during normal operation. The high-efficiency blue LED only requires a drive current of 0.1mA and with brief flashes, the overall effect on battery life is minimal. LED2 is lit continuously while an SMS is being sent, which takes about 25 seconds as it takes some time to

Parts List

1 Freetronics "Eleven" Arduino board or similar (Jaycar XC4210)
1 Seeed Studios Arduino GPRS shield (www.seeedstudio.com – Cat. SLD01098P)
1 SIM card
1 Freetronics Mega Prototyping Shield for Arduino (Jaycar XC4257)
1 UB2 jiffy box or similar (Jaycar HB6012, Altronics H0152/H0182/H0202)
1 9V DC regulated plugpack or similar supply
1 chassis-mounting DC socket to suit power supply (Jaycar PS0522 or PS0524)
1 small 6V SLA battery (eg, Jaycar SB2495)
2 6-way chassis-mounting terminal barrier strips (Jaycar HM3168)
4 M3 x 9mm tapped Nylon spacers
8 M3 x 6mm machine screws
2 M3 x 10mm machine screws
4 M3 nuts
2 M3 Nylon nuts
4 6.3mm red spade quick connectors
2 6.3mm piggyback spade connectors
1 2.1mm-ID DC power plug or cable with plug
2 mini SPDT chassis-mounting toggle switches
1 20-pin dual female splittable jumper wire, 300mm (www.seeedstudio.com CAB115C3O)
1 20-way snappable pin header, 2.54mm pitch
1 300mm length foam-cored double-sided tape
Light and heavy-duty hookup wire (various lengths and colours)

Semiconductors
1 green 3mm LED
1 blue 3mm LED
1 6.8V 1W zener diode
1 1N4004 1A diode

Resistors (0.25W, 1%)
6 22kΩ
2 2.2kΩ
12 10kΩ
1 22Ω 1W 5%

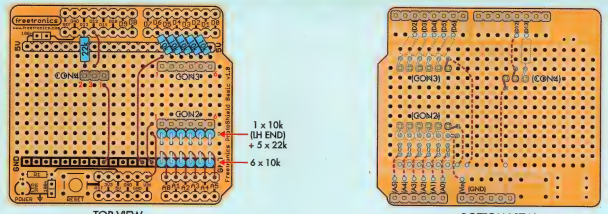


Fig.2: follow these layout diagrams to fit the components to the Arduino prototyping 'shield'. This has a grid of separate pads so insulated wires are added to make some of the connections. The pads around the edge connect to the I/O pins on the Arduino and GPRS modules. The bottom side overlay at right shows where additional links are required to connect components on the prototyping 'shield'. Make these connections using wire lead off-cuts or solder bridges as necessary.

'acquire' a mobile phone tower.

If the inhibit switch is set to prevent an SMS from being sent, the occurrence of an alert condition will cause the unit to rapidly flash LED2 for several seconds. This lets you check that the unit's operation is correct without using up SIM card credit.

LED2 remains off either if the unit is switched off or if the battery is flat and the unit has gone into power-saving mode. You can tell which is the case by simply examining the state of the power switch (S1).

GPRS shield

The GPRS shield/module is the most critical part of this project and the one that we are using is particularly easy to use and quite modestly priced, too. Is it from Chinese manufacturer and distributor "Seeed Studios" and can be ordered via their web page (see below). It has a SIM900 module from SIMCom which works particularly well but also has other circuitry such as a power supply for this module, SIM card holder and antenna.

There are actually two versions of this shield. For this project, we are using the original version (v1.0) but this is no longer available. The revised version (v2.0) functions more or less identically but has a few improvements. It has a more efficient switch-mode power supply, which means a slightly longer battery life. It also has an onboard antenna, eliminating the external whip.

The other improvements are a soft-start circuit for when it is powered on and off and some shielding to improve reception and protect the unit from static discharges. Since the original version is no longer available, constructors will need to use the revised version but it should be a straight drop-in replacement with no other changes required.

Communication between the ATmega328 microcontroller on the Arduino host board and the SIM900 are via an onboard serial port. This uses the 'software' serial port on the Arduino (on pins D7 & D8), leaving the 'hardware' serial port for debugging. The 'software' port uses more processor power but in our application, this is not important.

The GPRS module can be purchased from **www.seeedstudio.com/depot/gprs-shield-v20-p-1379.html** with free registered airmail postage or simply go to the Seeed Studios homepage (**www.seeedstudio.com**) and search for "gprs". More information on this module and how to drive it can be found at: **http://www.seeedstudio.com/wiki/GPRS_Shield_V2.0** and **http://rwsdev.net/wp-content/uploads/2013/02/Sim900-rev01-Application-Note.pdf**

Besides the bidirectional serial port, which is used to send commands and data (eg, SMS message contents), Arduino pin D9 is used to turn the GPRS module on and off; it operates in parallel with the onboard pushbutton. We use this to keep the GPRS module off to save power, except for when a message needs to be sent or received.

Power saving

We keep the microcontroller on the Arduino board in 'sleep' mode most of the time. It wakes up roughly once per second to read the state of each input, then calculates whether an alert condition exists. If so, it then checks whether a message has been sent recently. If all is normal or if a message has already been sent in the recent past, it immediately goes back to 'sleep'.

While using a pre-built Arduino

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	6	22kΩ	red red orange brown	red red black red brown
❑	12	10kΩ	brown black orange brown	brown black black red brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	1	22Ω	red red black brown	red red black gold brown

module saves a lot of effort, there is a disadvantage regarding its current consumption while idle. There are various LEDs which remain powered, the regulator has a relatively high quiescent current and so on, so it draws about 20mA even in sleep mode whereas a custom board could be designed to draw less than 1mA. Still, given the relatively large battery capacity, this isn't a major problem.

Software

While conceptually simple, the software for the Arduino board in this project is quite extensive. It uses the micro's "Watchdog Timer" to wake it up periodically to check the input states and this is also used as a time-keeping device. There are various counters to keep track of how long it has been since the last SMS was sent, how long since the last unprompted update, how long since it has checked for an incoming SMS and so on.

If sending a message, the unit also takes that opportunity to check if there are any incoming messages and if so, scans them for valid commands and takes the appropriate action. If a long period passes with no outgoing messages, it will power up the GPRS module anyway, to check for incoming messages. This interval is adjustable as it is a compromise between a fast response to incoming messages and battery life.

So that the unit can continue monitoring the inputs and sleeping (to conserve power), interactions with the GPRS module are handled by a simple "state machine". This means that after the GPRS module is powered up, the micro goes back to sleep, then wakes up a short time later and communicates with it – rather than remaining active while waiting for it to become ready.

If you want more details on how the software operates, it is well-commented so the best approach is to download and read it (from www.siliconchip.com.au).

Construction

The first step is to set up the GPRS module. The SIM card is fitted to the holder by sliding the cover and lifting it up, then sliding the card into the slots with the contact side facing the contacts on the PCB. Push it all the way home, then slide the cover back across to lock it in place.

You then need to check and possibly set the jumpers which control which serial port is used (hardware or software). There are two jumpers on a 3x2 pin header matrix. Set these for the software serial port ("SWserial"), as labelled on the module.

You can then plug the GPRS shield into the Freetronics "Eleven" board and apply power via a USB cable. You should see the green power LED light on the GPRS board and by holding down the power button on the GRPS board and by holding down the power button on the side of that board for about one second, it should power on. You will then see the red LED come on and after some time, a second green LED should start flashing with a cadence of 64ms on, 800ms off (ie, about one flash per second).

Assuming the SIM card is ready to go, this should change after a few more

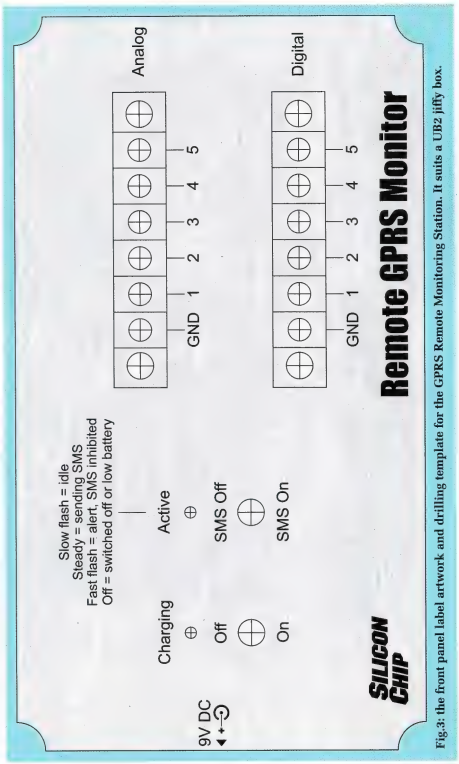
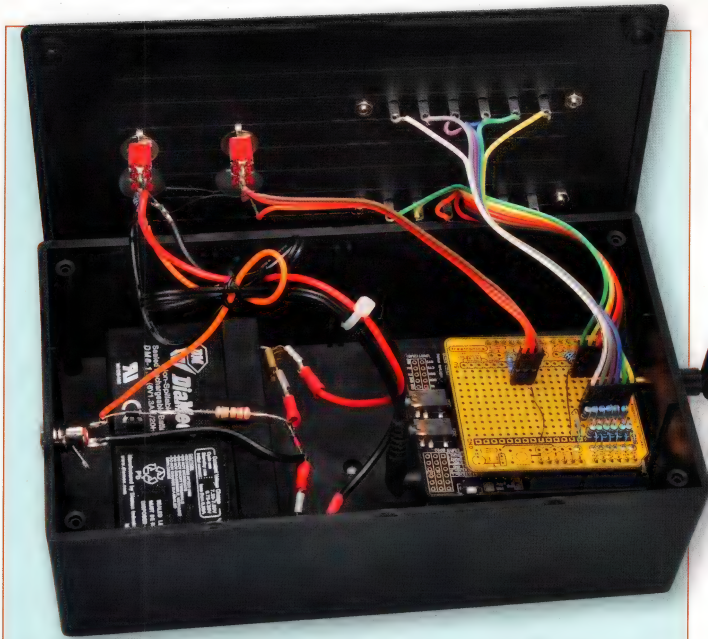


Fig.3: the front panel label artwork and drilling template for the GPRS Remote Monitoring Station. It suits a UB2 jiffy box.



This is the view inside the completed Arduino Remote Monitoring station. Most of the extra parts are mounted on the case lid and on the prototyping shield, with the latter then plugged into the headers on the GPRS shield. The battery is held in place on the bottom of the case using double-sided foam adhesive tape.

seconds to 64ms on, 3s off (ie, one flash per three seconds) to indicate that it has found the mobile network. Once you've verified that, you can unplug the USB cable and move on to the next step in the construction.

Interface board assembly

Next, fit the components to the prototyping shield. Start with the four pin headers on the underside of the board which plug into the GPRS shield (these are supplied with the PCB). The easiest way to ensure they are fitted straight is to push the 4-pin headers into the sockets on the Arduino host board, then place the prototyping shield on top and solder the pins.

Follow with the resistors, as shown on the layout diagram of Fig.2, starting with those which are flat on the board and following with the vertical ones. It's a good idea to bend some of the leads over before soldering them and trim them slightly longer, so that they can be used to form the bottom side links later.

You can then fit the top-side pin headers, followed by the wire links, which should be made with small gauge insulated wire. We used "Kynar" wire-wrapping wire.

When all the parts are on the board, finish by making the solder bridges on the underside as shown in Fig.2. For those where you were not able to leave sufficient lead length, use short lengths of lead off-cuts. Alternatively, you can bridge solder between adjacent pads, although given the relatively wide spacing, this can be tricky.

When finished, plug this board into the GPRS shield.

Case preparation

The next job is to drill the required holes in the lid. Copy the label (Fig.3) and use this as a drilling template. You

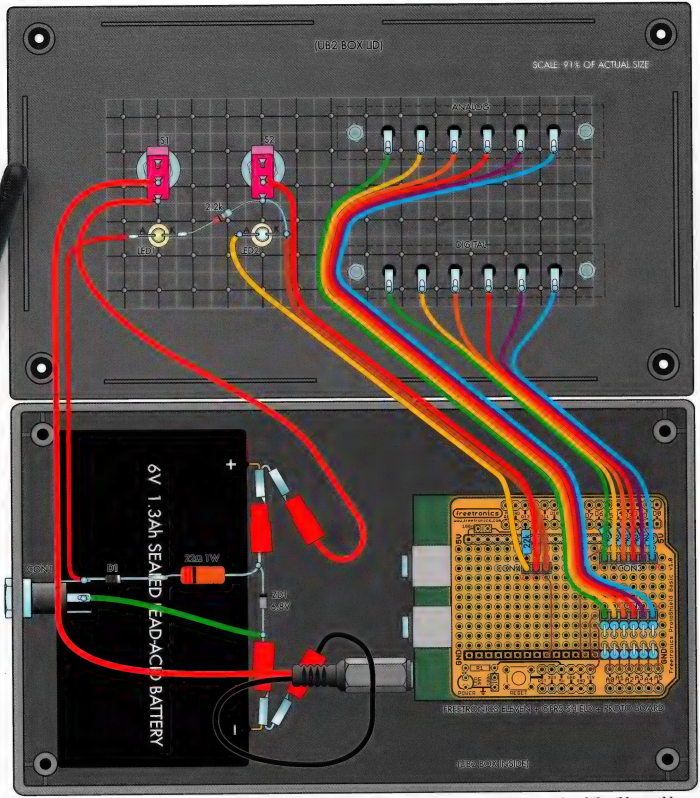


Fig.4: the complete wiring diagram. The battery, switch and LED connections are mostly 'air-wired', while ribbon cable fitted with individual pin sockets is used to plug into the headers on the Arduino interface shield.

can also download this as a PDF file from the SILICON CHIP website (free for subscribers) and print it out. Once the holes have been drilled, remove the template, then print or copy another label onto photographic paper. This label can then be laminated and attached to the lid using double-sided tape or spray adhesive, making sure that the hole locations in the label line up with the holes in the panel.

The holes in the label can then be cut out using a sharp hobby knife.

Next, fasten the two 6-way terminal barrier strips to the lid using M3 x 10mm machine screws and nuts, then mount the two toggle switches in place. The two LEDs can then simply

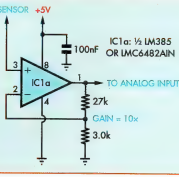


Fig.5: a simple gain stage to interface sensors with low output voltages to the Remote Monitoring Station. The LM358 can be used where the output level will be below 3V at all times; the LM6482AIN can give an output of up to nearly 5V. Gain can be calculated as (27kΩ + 3kΩ) ÷ 3kΩ = 10 and using this formula, resistors can be selected for different gain values.

be pushed through their 3mm holes and glued into place using either hot melt glue or silicone sealant (or you can use plastic bezel mounting clips).

The next hole required is that for the DC input socket. This goes in the side of the case, as shown in the photos. Place it slightly higher than half-way up the side of the case and centre it between the two adjacent corners. Enlarge the hole using a tapered reamer until the DC socket fits through, then secure the socket in place.

Assembly

You can now fasten the SLA battery down into the case using two strips of double-sided foam tape (see Fig.4). That done, complete the rest of the wiring as shown in the wiring diagram – see Fig.5.

You then need to mount the Freetronics Arduino module in the case. Unplug the GPRS shield/prototyping board and use the Arduino board as a template to drill the four mounting holes in the bottom of the case. That done, fit four tapped spacers using short M3 screws, then use more screws to hold the Arduino module on top and plug the other boards back in.

Note that we had to put ours adjacent to the edge of the case, so that the external antenna connector passed through the side. However, as stated above, the revised GPRS module has an internal antenna, so this is not required.

For the connections from the pin headers on the Arduino module, the easiest method is to cut lengths of splittable jumper wire. These generally come as 20-way rainbow cable with separate female "Dupont" connectors for each strand. You can get this from Seeed Studios at the same time as you order the GPRS module (see parts list) but similar cables are available from other sources such as Little Bird Electronics (http://littlebirdelectronics.com).

Individual female-to-female header jumper cables can also be used but tie them into bundles to keep them neat. Either way, strip the cut ends and solder them to the terminal barrier lugs, switch lugs and LED leads as shown.

Now for the power supply wiring. You can crimp the quick connectors to the wires if they are sufficiently thick but component leads are too thin and will need to be soldered; do this quickly so as not to melt the glue holding the plastic surround in place.

Perhaps the easiest approach is to push the piggy-back terminals onto the battery connectors, then trim the leads of the zener diode so it just fits between these and solder it to two crimp connectors. Watch the polarity when you plug this in or it will get very hot, very fast! You can then solder the connections from the DC socket to the exposed zener leads. As shown, the ground connection is direct whereas the positive side goes via a diode and 1W resistor wired in series.

For the power connection to the Arduino board, either cut a DC power cable to length (eg, from a dud plugpack) or make up a twin-core cable with a DC plug. Either way, test the plug for fit first – a 2.5mm inner diameter DC plug will go into the socket on the Arduino board (2.1mm ID) but will not make a reliable connection.

You can then plug the two remaining quick connectors into the battery piggy-back terminals and solder the free ends of the DC power cable as shown. Complete the wiring as shown in Fig.4, including the wiring for the two LEDs.

Connecting sensors

Various sensors with analog outputs can be connected to the analog inputs on this device however not all will have suitable voltage swings. As specified, the inputs have a resolution of approximately 16mV. This is not suitable for reading the output of a sensor with, say, a 0-100mV swing.

To increase the sensitivity of a given input, you can change the resistive divider. Best resolution is about 5mV, with the lower 10kΩ resistor in the associated divider removed. That will be sufficient for say a temperature sensor with an output of 10mV/K, giving a resolution of about 0.5°C and a range of about -250°C to +250°C.

However, for a pressure sensor which gives 25mV full scale, this is still no good. In that case, you need to wire up an op amp to give some gain. Fig.5 shows the basic arrangement but we'll leave the rest of the details up to you. Some sensors may require a more complex arrangement; refer to the manufacturer's literature.

Set-up

Before programming the Arduino board, you need to customise the settings for your situation. Download the Arduino IDE (Integrated Development Environment) from http://arduino.cc/en/main/software and load it up. You will then need the "sketch" for this project, which is available from the SILICON CHIP website (free for subscribers).

Open up that 'sketch' (.ino file extension) which will launch the Arduino IDE. The first couple of pages of code contain the settings, as shown in Fig.6.

The first entry is the phone number to receive alerts, which goes within the quotation marks. It must be in international format, ie, for Australia start with "+61" and then follow with the area code (drop the first zero) and the rest of the phone number. As shown, Australian mobile numbers will thus start with "+614".

The next entry is the SIM card PIN. You only need to set this if your SIM card has PIN protection. If so, make sure this is correct! Most new SIMs either have no PIN or it is set to the default value of 0000. Again, put it in quotes.

Following that is a field to enter your carrier's "Message Centre" phone number. This is a number through which messages are routed and can usually be found somewhere on the carrier's website. For example, our test SIM was on the Vodafone network and we found the appropriate number at http://support.vodafone.com.

Software Settings

```
typedef struct { float upper; float lower; float gain; } adiv;
typedef struct { float minval; float maxval; signed long delaysec; } alimit;
typedef struct { unsigned char state; signed long delaysec; } dlimit;

// Phone number to send alerts to:
char    SMS_Destination[32]                 = "+614xxxxxxxx";
// PIN number for the SIM card, if used:
char    SMS_PIN[5]                          = "0000";
// SMS message centre number for your carrier:
char    SMS_MSG_CENTRE_NUM[32]              = "+614xxxxxxxx";
// SMS command password, must be contained in a received SMS for any commands to work
char    SMS_PASSWORD[]                      = "simon says";
// Send an SMS once a day (ie, 24 hours x 60 minutes x 60 seconds, 0 = off):
unsigned long SMS_send_interval             = 60*60*24;
// Never send an SMS more than once every half hour:
unsigned long SMS_min_send_interval         = 30*60;
// Check for SMS reception every half hour (0 = off)
unsigned long SMS_recv_check_interval       = 30*60;
// How long to suppress messages for after a STOP command is received (default eight hours)
unsigned long SMS_suppress_time             = 8*60*60;

alimit alimits[] = { /* analog input configuration */
 { /* min voltage */ 5.5, /* max voltage */ 6.9, /* delay (sec) */  60 }, // battery voltage
 { /* min voltage */ 0.0, /* max voltage */ 16.0, /* delay (sec) */ 15*60 }, // input A1
 { /* min voltage */ 0.0, /* max voltage */ 16.0, /* delay (sec) */ 15*60 }, // input A2
 { /* min voltage */ 0.0, /* max voltage */ 16.0, /* delay (sec) */ 15*60 }, // input A3
 { /* min voltage */ 0.0, /* max voltage */ 16.0, /* delay (sec) */ 15*60 }, // input A4
 { /* min voltage */ 0.0, /* max voltage */ 16.0, /* delay (sec) */ 15*60 } // input A5
};

dlimit dlimits[] = {
 { /* expected state */ 1, /* delay (sec) */ 15*60 }, // input D1
 { /* expected state */ 1, /* delay (sec) */ 15*60 }, // input D2
 { /* expected state */ 1, /* delay (sec) */ 15*60 }, // input D3
 { /* expected state */ 1, /* delay (sec) */ 15*60 }, // input D4
 { /* expected state */ 1, /* delay (sec) */ 15*60 } // input D5
};

adiv adivs[] = { /* analog input dividers */
 { /* upper resistor (kOhms) */ 10.0, /* lower resistor (kOhms) */ 10.0, /* gain */ 1.0 }, // battery voltage divider
 { /* upper resistor (kOhms) */ 22.0, /* lower resistor (kOhms) */ 10.0, /* gain */ 1.0 }, // input A1 divider
 { /* upper resistor (kOhms) */ 22.0, /* lower resistor (kOhms) */ 10.0, /* gain */ 1.0 }, // input A2 divider
 { /* upper resistor (kOhms) */ 22.0, /* lower resistor (kOhms) */ 10.0, /* gain */ 1.0 }, // input A3 divider
 { /* upper resistor (kOhms) */ 22.0, /* lower resistor (kOhms) */ 10.0, /* gain */ 1.0 }, // input A4 divider
 { /* upper resistor (kOhms) */ 22.0, /* lower resistor (kOhms) */ 10.0, /* gain */ 1.0 } // input A5 divider
};

float Low_Battery_Level = 5.0; // do not flash LED or send SMS with battery below this voltage
```

Fig.6: first lines of the software showing the settings which can be customised to suit your application. Text written /* like this */ or prefixed with a double-slash ("//") indicates a comment which has no effect on the operation of the software.

au/articles/FAQ/Vodafone-message-centre-number

The next entry is the SMS command password. You can control the unit remotely by sending it messages containing certain text commands but they are ignored unless the message also contains this password. The default is "simon says" but you can change it to something else to protect against the unlikely event that somebody else figures out your unit's phone number.

The next four settings are time intervals, specified in seconds. You can use "*" as a multiplication operator to make setting them easier, eg, 4 * 60 * 60 works out to four hours (four hours times 60 minutes per hour times 60 seconds per minute) as does 4 * 3600.

The first is the interval at which the unit will send you status updates, regardless of the input states. The default is once per day (24 hours). However note that the time of day that the mes-

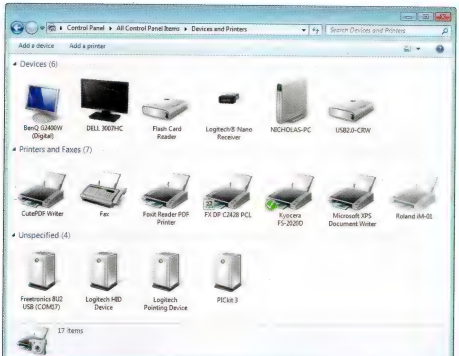


Fig.7: before programming the Arduino board, it must first be plugged into a USB port and assigned to a serial port as shown here (Windows 7).

sages are sent is determined by when the unit is first switched on and if it loses power completely, that will reset the timing. Also, the time-keeping isn't exact so it will likely drift over time (although you can reset the timing remotely). If you don't want to get messages unless something is wrong, set this item to "0".

The next time interval specifies the minimum message sending interval. The default is every half hour. So if there is a continuous alert, you will get at most two messages per hour until the alert goes away (or you tell it to stop).

The third time interval determines how often the unit powers the GPRS module up to check for incoming messages. The default is half an hour but as explained earlier, a shorter time will give a faster response to incoming messages but use up the battery faster. This can also be set to zero, in which case the unit will only check for incoming messages after sending a message.

The final time interval sets how long messages are suppressed after an appropriate command is received by the unit. The default is eight hours. Note though that you can send another command to tell it to resume sending messages to override this if necessary.

Input settings

Now you will need to tell the unit the expected state of each input that is connected, ie, define what will trigger an alert. This is done separately for the five analog inputs and the five digital inputs.

Start with the analog inputs. The first line sets the acceptable voltage range for the internal battery. The default is for a minimum of 5.5V and a maximum of 6.9V, with a delay of one minute. So if the battery voltage drops below 5.5V or goes above 6.9V and stays there for more than a minute, an alert condition will occur and a message will be sent (unless messages are being suppressed).

The following five lines work the same way except that these define the minimum and maximum allowed voltages for the five external analog inputs. If an input is not connected, leave the range as 0-16V so it can never generate an alert.

If you want to generate an alert when an input is within a voltage range (rather than outside it), swap the minimum and maximum values. So, for example, if the minimum is set to 9V and the maximum to 8V, the unit will generate an alert when the voltage at that input is in the range of 8-9V and not if it is below 8V or above 9V.

Next, set the expected states for the five digital inputs and their associated alert delays. If a digital input is not connected, set the expected state to 1 (high). If an input is connected to a relay/switch with the other end to ground, that input will change to 0 (low) when the contacts are closed.

Regarding the delay setting, say you want to make sure a pump runs at least once an hour and the switched +12V supply to that pump is connected to a digital input. Set the expected state to 1 and the delay to be 60*60 or 3600 seconds (one hour). Thus, when the pump switches off, the alert timer starts. If it does not go high (switch on) again within an hour then an alert will be generated.

If you want to set a maximum interval to generate an alert (eg, to ensure a pump doesn't run too often), put a minus sign in front of the period, eg -3600.

Finally, if you have changed any of the analog input divider resistors, update the values in the "adivs" table so that the software can scale the input voltages correctly. You will also need to set the gain to a figure other than 1.0 if you are applying any gain to the signal being fed to the input.

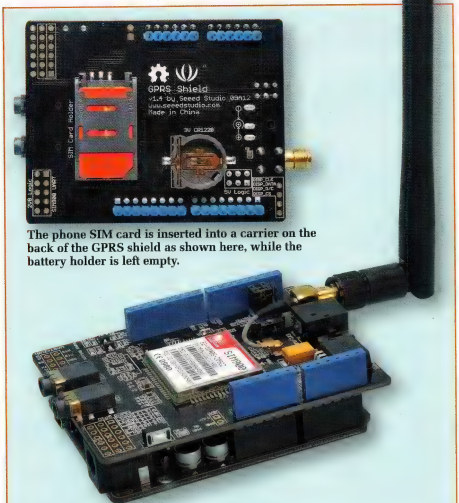
Programming it

Having finished altering the settings to suit your usage case, in the Arduino IDE, press CTRL+R or select the "Verify / Compile" option from the "Sketch" menu. After a few seconds, you should see a message at the bottom of the window giving the "Binary sketch size". If you don't, or if there are error messages, fix any mistakes you have made in the settings and verify again until it succeeds.

You can then plug the Arduino board into your PC using a USB Type A to Mini Type B cable (typically supplied with the Arduino board) and upload the software and settings by pressing CTRL+U or selecting "Upload" from the "File" menu.

Note that when you plug the Arduino into your PC, it may take some time for it to be fully detected and you must wait for this to occur before uploading the sketch or it will fail. In Windows, you can check that it has been detected by going to the "Devices and Printers" section of the Control Panel.

Fig.7 shows the result on a Windows 7 PC. As you can see, the Arduino board is detected as a "Freetronics 8U2 USB" on COM17. If you then open the "Tools" menu in the Arduino IDE, under the "Serial Port" sub-menu, you



The phone SIM card is inserted into a carrier on the back of the GPRS shield as shown here, while the battery holder is left empty.

This view shows the GPRS shield board plugged into the Arduino board, ready for installation in the case.

can then select COM17. You should then see an indication that it is connected in the bottom-right corner of the IDE and you can then proceed to upload the software.

After a successful upload, unplug the USB connection, plug in the DC socket from the battery power supply and your unit should be ready to test.

Testing

Start with the SMS inhibit switch in the "SMS Off" position. Apply charging power and the green LED should come on. The voltage across the battery should be slowly rising.

Switch the unit on and the blue LED should start to flash at 1Hz (with a short on-time). Trigger an alert condition and after the set delay, the blue LED should flash rapidly for a few seconds and this will repeat once per minute.

Next, set the inhibit switch to "SMS On" and after a short delay, the unit should send an alert SMS to your phone. If this fails, the LED will flash rapidly, as it did when inhibited. In this case, check that the SIM is valid, is inserted correctly and you have set the correct PIN.

Power supply

Since the charging arrangement is very simple, the supply needs to have reasonable regulation. An unregulated 9V plugpack is not suitable (without increasing the current-limiting resistor value). A 9V regulated plugpack or small 9V solar panel should be fine and either can be connected directly to the power input.

If you want to charge the unit from a 12V battery or use an unregulated 9-12V plugpack, the 1W current-limiting resistor should be increased to at least 68Ω.

Operation

Once you have verified it's working, the unit is pretty much just a "set and forget" affair. However, there are some commands which may be sent remotely if necessary. You should be able to determine the unit's phone number by waiting for it to send you a message, then adding the remote number to your phone book.

If you send a message to this number containing the password string (set earlier), plus at least one command, the unit will act accordingly once it has received that message. As noted earlier, this won't necessarily be immediate. You can include multiple commands in a message. The commands are:

- **"suppress"** – the unit will not send you any more messages for some time, unless you send a "resume" command. This time is set in the Arduino software header and defaults to eight hours.
- **"resume"** – cancels any "suppress" command.
- **"status"** – causes the unit to immediately send an input status report.
- **"reset"** – resets the timing of periodic status updates. If, say, the unit is set to send an update every 24 hours, the next update will be (roughly) 24 hours from the reception of this command.
- **"redirect <phone number>"** – send future messages to the specified phone number instead of the one configured in the software. If power is lost (eg, the battery discharges totally), it will revert to the original number. The phone number must start with a + followed by the country code, area code and phone number.

The messages sent by the unit have the following format:

Batt: 6.21V [OK] Analog: 0.00V [OK] 0.00V [OK] 0.00V [OK] 0.00V [OK] 0.00V [OK] Digital: 1 [OK] 1 [OK] 1 [OK] 1 [OK] 1 [OK] 1 [OK]

This shows the battery voltage, the voltage at each analog input in sequence (1-5) and then the status of each digital input in sequence (0/1). If any of these is outside its specified range, the "[OK]" is replaced with an exclamation mark, followed by an indication of how long this has been the case.

This example message is 123 characters long and the maximum length of a standard SMS is 160 characters. The message length can increase slightly if it displays voltages higher than 9.99V or if any of the inputs is out of range. The maximum length is around 150 characters and so will always fit in a single SMS. SC

SERVICEMAN'S LOG

Miracle repairs can take a little longer

Dave Thompson*

There used to be a popular saying that I remember seeing printed and hung on a wall in many workshops and offices. It read "The impossible we do immediately, miracles take a little longer", or something to that effect. I imagine many a serviceman's workshop once had a similar notice posted on the wall.

In this business, some successful repair jobs do seem like miracles – those jobs where everything seemed impossible but against all odds (and often logic and reason), things turned out alright. And while we sometimes can't take all the credit for these miraculous outcomes, we will still accept payment and quietly praise the gods that it all worked out in the end.

I've personally experienced a few such miraculous jobs, the best one involving data recovery from a damaged external hard disk. The fix involved some knowledge, skill and educated guesswork but the main component turned out to be a healthy dollop of pure dumb luck.

This particular hard drive had been dropped by the client and was no longer detected when plugged into the USB port of a computer. It's not an uncommon scenario – many external drives have a hard life, mainly because their portability implies that they are somehow more resilient and can take more punishment than a standard (internal) hard disk, which is simply not the case. Typically the only concession to shock protection for these drives are half a dozen small rubber mounting washers which can hardly be expected to safeguard the drive from being knocked about when floating around someone's backpack or car boot.

In my experience, many computer users don't appreciate just how fragile hard drives are and some clients have even told me that they had no idea they could fail! Yet fail they do with monotonous regularity, regardless of type and usually all by themselves, without ever being dropped or subjected to any other obvious abuse.

For those interested in such things, there are various videos available online showing hard drives in operation and these give an idea of just how hard these devices work. Most people who view these videos are amazed that hard drives last a week let alone an average

Items Covered This Month

- Hard disk drive data recovery
- PC power supplies
- Lumina vacuum cleaner
- LED torch repair
- Westinghouse FJ208S freezer repair

*Dave Thompson runs PC Anytime in Christchurch, NZ.
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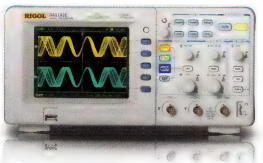

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of about four years without wearing out or even dropping a byte of stored data along the way.

Anyway, back to the hard drive in question. It was enclosed in a moulded plastic case and boasted connectors for external power and USB. With everything plugged in, the built-in activity LED stayed firmly red instead of flickering in tune with hard disk activity. So that wasn't a good start.

Even more ominous, you can also usually hear a hard drive spool up but this one was dead quiet – also a bad sign.

Still, with a dropped hard drive, there is always a chance that the on-board electronics or the connectors themselves are the cause of the problem. In these cases, the only reasonable troubleshooting procedure is to remove the drive from its enclosure and plug it directly into a computer, thus bypassing any problems with the caddy itself. If the gods are smiling, the drive is detected and successfully mounted by the operating system, after which the contents can be read and copied to another drive.

After that, if all the usual tests prove satisfactory, the drive is considered to be OK and can be installed in a new external enclosure. The client can then carry on as if nothing untoward had happened, although they really should be counting their blessings (and making sure they back up in the future).

Unfortunately, as most computer servicemen know, this rose-tinted example isn't a typical outcome. More typically, the drive will not be recognised by the system and we have to break the bad news to the client that their data is irretrievable.

And that's exactly what happened in this particular case. When I plugged the drive into my recovery computer, the BIOS didn't "see" it at all and that meant that it was pointless booting into Windows. After all, if the hardware doesn't recognise that the drive is connected, then neither will Windows or any fancy data-recovery software that may be used.

Usually, this is when I tell the client that I cannot do anything further because the drive is dead and that's the end of it. In an external hard drive data recovery situation, I typically break the drive enclosure open in front of the client after advising them that the drive is likely ruined anyway, so they have nothing to lose. I then plug it into my recovery hardware out back while they wait in reception. That way, we both know straight away whether there is any hope of my being able to do anything with the drive. And on the rare occasion they want to send the drive off to a dedicated data-recovery house, at least what I've done hasn't made things any worse.

THE IMPOSSIBLE WE DO IMMMEDIATELY, MIRACLES TAKE A LITTLE LONGER

Misconceptions

There are many interesting opinions (and misconceptions) as to what these data recovery houses do. Some believe they have magical equipment that can resurrect and recover data from any hard drive, no matter how damaged it may be, which is why they charge many hundreds (if not thousands) of dollars for their services.

The simple truth is that yes, they do have clever tools and people with lots of experience in hard drive mechanics. However, if the disk's platters are physically damaged, recovery is unlikely no matter how clever the technicians and tools are.

If the drive's electronic circuitry is faulty, the most common method of recovery is doing what's known as a 'platter swap'. In this case, the technician removes the platters from the dead hard drive and mounts them in a known-working version of the same make and model of drive, thereby enabling the data to be recovered. Some companies also have the hardware to reprogram a drive's corrupted firmware in order to get it going again.

On the other hand, amateurs like me who attempt such repairs usually make things worse, which is why I don't usually do it.

There are other considerations; a speck of dust can ruin the whole process so a platter swap needs to be

done in an ultra-clean environment and that usually means a dust-free work cabinet at the very minimum. A specially-made "clean" room is even better but as you can expect, all that cleanliness doesn't come cheap. There are sites on the internet showing how to build do-it-yourself clean rooms or cabinets but it's a lot of time, money and effort if you don't plan on doing a lot of data recovery work.

The same can be said about the several hundred bucks you'd also have to shell out for the specialist jigs and tools required to safely disassemble hard drives. It's true a simple screwdriver with the right bits can be had for a few dollars and with this you can remove the circuit board and the case screws. However, as soon as you remove the main top screw, which holds the top of the drive's head assembly and fine-tunes the head's alignment, you really need some special jigs and other tools to ensure consistent success.

What's more, even if you have these jigs (called 'head combs') to keep the heads from touching the platters while the latter are removed, you still need a very steady hand. These combs are designed specifically for each make and model of drive head assembly and are often fragile themselves and thus difficult to use properly.

If you have a single platter drive, you've only got one set of heads to worry about (one on top and one underneath). However, if you have a multi-platter drive, a challenge presents itself; the platters must be removed and replaced into the working chassis aligned exactly as they came out of the old drive. If they move in relation to each other by even the slightest amount, any stored data is instantly rendered gibberish and even if you do manage to get the drive going enough to be recognised by the computer's BIOS, the data will be gone.

Of course, there are special tools available to help keep platter azimuth consistent but these are quite expensive and you do have to learn how to use them. In short, pulling a hard disk drive apart to recover data is a task that really sorts the men from the boys.

I hate being defeated

Being a serviceman who hates being defeated by mere hardware, I looked very carefully into this data recovery malarkey some time ago. Initially, I toyed with the idea of turning an under-utilised upstairs office (mine) into a bona-fide clean room employing a home-made dust-filter system and a vacuum cleaner from the local bargain shop.

At the time, I could have accomplished it relatively easily and inexpensively but a natural disaster and a couple of years of follow-up earthquakes put the kybosh on the idea – the resulting proliferation of liquefaction dust in the atmosphere and seemingly ever-shaking workbenches is just not conducive to setting up a contaminant-free data recovery workspace.

Besides, my own informal polls conducted among those requiring data recovery indicated a distinct trend. While most were happy to pay less than a couple of hundred dollars for me to recover their data using existing methods, the vast majority baulked at paying more than that. It really didn't take much more for them to decide that they could in fact do without those emails, spreadsheets and baby photographs that seemed so important before they heard how much it might cost to recover them.

There were other factors too; given the cost of setting up even an inexpensive clean room and purchasing the barest minimum of specialist tools, it would take years, to get a return on my investment. What's more, in a few years, almost every computer hard drive will be a solid-state device, so there's no point investing money to do this type of data recovery anyway.

Back to the faulty drive

OK, so that's all by way of background. What about my client's dead external drive?

As luck would have it, I had an identical working example of this particular make and model which we utilised as a workshop spare. And while the client wasn't prepared to pay thousands to recover his data, he was prepared to let me try a platter swap, even after I'd explained that it would probably result in the data being completely unrecoverable if (as I quietly expected) it all went pear-shaped.

As mentioned, the challenge here involves getting the heads out of the way while the platters are removed, while maintaining the positions of the platters in relation to each other. Fortunately, this drive was a single-platter model, so platter alignment was one thing less to worry about.

However, we were still faced with removing the heads and platter without the two touching. A good friend of mine owns a laser engraving/cutting machine so after doing a lot of measuring and research into head-comb design, I whipped up the pattern for a suitable comb using my graphics software and emailed the relevant files off to my buddy Gary. He then laser-cut several combs for me out of various types of plastic.

In practice, the comb is slipped between the heads and the chassis of the drive. As a comb is pushed in, the heads are spread apart and held a few millimetres clear of the platters. The whole head assembly can then be turned out of the way with the comb in place and removed without fear of any of the heads touching the platter.

But even with the comb, it isn't all plain sailing; I still had to be very careful removing the head assembly. I know what you're thinking; all I need now is one set of combs for every make and model of hard drive and I'm half way towards providing a full data recovery solution. The problem is, given the number of people not opting for a more expensive service, it isn't worth the investment.

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in SILICON CHIP? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

Anyway, having successfully removed the heads from the dead drive, the same comb was then used to remove the heads from the known good drive. It was then used again when putting it all back together, after swapping over the platter from the client's drive.

At this stage, I had serious doubts as to whether it would work, given I'd swapped the platter without a clean room and without most of the specialised equipment usually needed. You can imagine my amazement then when the reassembled drive was detected and subsequently mounted by Windows when I connected it to my data recovery computer. What's more, I was then able to fully recover the client's data.

This outcome was more down to luck than skill and while I could probably do the same thing with other faulty drives, I'd need the correct head combs and a good matching hard drive in each case. And as anyone who has tried this knows, finding an identical donor drive to match a dead unit is almost impossible given just how many variations there are in make, model and firmware revisions.

In short, this was simply one of those 'miracle' jobs where the planets aligned and the gods smiled.

My second miracle

Another miracle job happened not long ago when a tourist dropped into the workshop with a USB flash drive that no longer worked. It didn't take a technician to figure out why; when shaken, the thing rattled and you didn't need to be Einstein to figure out that something inside had come adrift.

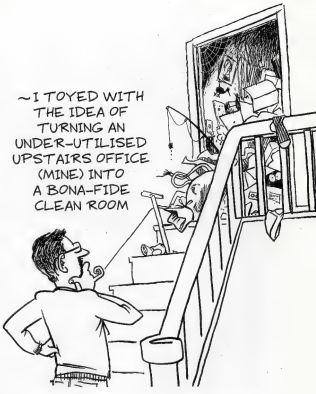
I informed the client that I'd have to crack open the plastic case to check it out and he agreed, accepting my advice that the data was probably unrecoverable anyway. As I prised the case apart with a craft knife, one of the four memory chips inside fell out onto the counter, the result of poor soldering during manufacture.

The client was very keen to recover the data, so I suggested I try re-soldering the chip to the circuit board. I had serious doubts as to whether it would work but since I have a rather nifty set of soldering tools, I figured it was worth a shot.

I used a soldering technique I'd employed before when soldering a JTAG socket to my mobile phone. First, I spread soldering flux over all the bare pins on the circuit board and then used its adhesive properties to hold the chip in place while I wiped down each row of pins with a well-tinned soldering iron. The flux melted and the tiny connections soldered as if by magic.

A quick check under a magnifying lamp confirmed that all the connections were sound. I was still convinced it had all been a waste of time but when I plugged it into a PC, all the files were visible. I glued the case back together and the client went away, happy as Larry.

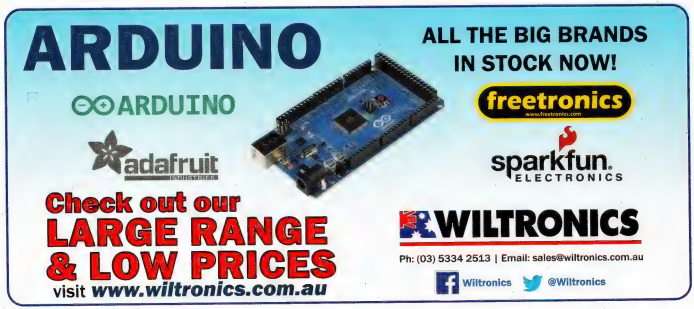
So once again, although some skill was involved, the eventual outcome was down to the God of Servicemen providing yet another miracle!



PC power supplies

PC power supplies are generally not worth repairing but sometimes it pays to give it a go. You win some and you lose some according to regular contributor B. P. of Dundathu, Qld . . .

From time to time, dead and/or dying PC power supplies come into my possession from various sources. My usual modus operandi is to give them a quick check with a basic LED Power Supply Tester to see if they work. If they don't work, they are stripped for parts. Conversely, if they work with the



Serviceman's Log – *continued*

The upright freezer & the incorrectly wired thermostat

R. B. of Nunawading, Victoria recently tracked down a couple of faults in his upright freezer, one of which was there from new. Here's his story ...

A number of years ago, we purchased a Westinghouse FJ208S upright freezer. This freezer is a frost-free type and it worked well, although I was surprised that the compressor appeared run most of the time. However, as it's located in the laundry and cops a beating from the hot summer sun, I wasn't overly concerned about this, particularly as it was worked well and kept the food frozen.

And then, about two or three years after we purchased it, I noticed a build-up of ice in the bottom of the freezer. I didn't do anything about this until one day I noticed water on the floor, in front of the unit. As a result, I removed the wire basket from the bottom of the freezer and gradually removed the ice build-up. This subsequently became a regular task every nine months or so, depending on the quantity of ice forming on the bottom.

This went on for some time until, one day, I retrieved a tub of ice-cream from the freezer and found it to be a bit softer than normal. I had a mechanical freezer thermometer, so I placed it in the unit and checked it at regular intervals. This revealed that the temperature was varying substantially and this meant that the freezer's thermostat was possibly faulty.

I recalled that in February 2009, SILICON CHIP published a construction article for the Tempmaster Mk2, which could be set for a range of 2-19°. As a result, I emailed the magazine to see if the circuit could be modified so that it could be set at a lower temperature, with the idea of putting it into the freezer and bypassing the internal thermostat.

I received a prompt reply advising that I could change the "3.3kΩ resistor between trimpot VR1 and test point TP1 to 2.7kΩ" to give a range of -23°C to -2°C. As a result, I purchased the kit from Jaycar, constructed it with the modification and set it up in the freezer. I then monitored the mechanical thermometer in the freezer to set the controller to the required temperature and it then worked well apart from a relay chatter issue which, following another email to SILICON CHIP, was soon resolved.

Some time later, I was having coffee one day with a mate (who had purchased the same model) and I explained to him how I had modified our freezer. He had also found a build-up of ice in his freezer a couple of years after purchase and after some investigation, had discovered that the mechanical timer controlling the defrost cycle had seized.

During normal operation, this timer periodically activates a heating element at the back of the freezer. This melts any build-up of ice which then drains to an open container on top of the compressor, where it eventually evaporates. My friend had tried freeing up the faulty timer but when this didn't work, he replaced it with a new unit.

Knowing that I was interested, my friend also gave me all the details re-

LED Tester, they are then checked with a Digital Power Supply Tester. If they pass this test, I then take a closer look, to determine what faults they have.

The fault has to be simple though. Finding complicated faults can be difficult and time-consuming, so it's not worthwhile doing given the low cost of new units. However, it can be worthwhile repairing the better-quality supplies if they just need a few capacitors replaced or a dry joint resoldered.

Recently, I was given two suspect supplies, one of them a Thermaltake 430W unit. When I had a spare minute, I set about testing them. I began by plugging the Thermaltake supply into the power and hit the power switch, only to be greeted by a very loud bang. The power also tripped out, so I immediately unplugged the unit and went outside to reset the safety switch.

Next, I removed the cover from the supply and found that it looked like new inside. There was no obvious sign of any fault at first glance but then I noticed a small fragment from a high-voltage capacitor in one corner of the case. I tipped this out and then looked around the input area and found that one of the suppression capacitors had blown to pieces.

So what had caused this to happen? It appears that a power surge had overloaded the suppression capacitor and this had shorted its Active side to Earth. This would have taken out the power at the time but at least it protected the rest of the power supply from damage. The shorted suppression capacitor then exploded and tripped the safety switch when I subsequently tested the supply.

I grabbed the remains of the dead capacitor with long-nosed pliers and destroyed it completely, in order to remove it from the PCB. I then grabbed my multimeter and checked the 240V input pins to verify that nothing was shorted to earth (the reason the safety switch had tripped).

This gave the all-clear, so I plugged the supply into power and switched it on. Nothing untoward happened, so I grabbed my LED Power Supply Tester, plugged it in and found that the supply now worked. Further checks with my Digital Power Supply Tester then showed that all the output voltages were good.

After that, it was simply a matter of removing the PCB and replacing the blown suppression capacitor with one salvaged from a dead power supply.

Having successfully repaired that unit, I moved on to the second unit but found that it was almost dead, with only the 5V standby rail working. It was wrecked and yielded several useful spares that can be used for other repairs.

Lumina vacuum cleaner

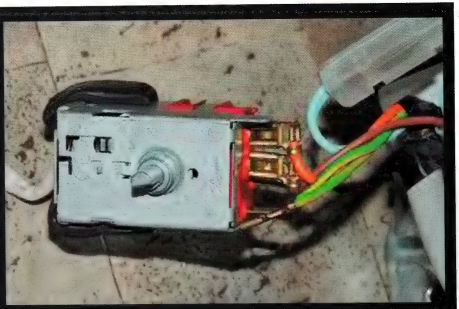
Another piece of gear that I recently saved from going into landfill was a Lumina upright carpet sweeper-vacuum cleaner. It was given to me by a friend who knew that I "fixed things", with

garding the steps he went through to replace the timer and even where to source a new one. And so, soon after, I purchased one and removed the inside back panel from the freezer so that I could access the existing timer. It too was frozen (I guess quite appropriately in a freezer!).

Anyway, the residual ice was removed and the new timer installed. That done, I figured that the freezer would now be back to normal operation but I think Murphy must have been looking on. Although the freezer was getting cold, down to -20°C, it again appeared that the compressor was running more often than it should.

This was becoming annoying and I now figured that it was time to replace the thermostat with a new one. Before disconnecting the wiring, I drew a diagram and took several photos to ensure that I connected the replacement correctly. This was eventually done but I was concerned at just how close two of the three connections were (pins 4 & 6). In fact, it was possible to make them contact each other just by angling them slightly on their mounting lugs, so I put some heatshrink sleeving on one of them.

I then began thinking that this



was rather unusual so I grabbed the multimeter and sure enough, the two connections were common. So there was no need for the heatshrink after all! I then went back to the diagram my mate had sent me and suddenly realised that the original thermostat had been incorrectly wired in the factory. It was effectively bypassed and the compressor had been running almost constantly since new!

Having found this error, I connected the thermostat wires correctly (ie, leads to pins 3 & 4 plus the Earth connection) and the freezer then ran perfectly. Pin 6 of the thermostat isn't used here as there is no light in the freezer. I can't confirm this but I assume that when the compressor wasn't running, it had become too hot and some sort of safety device had shut it down.

So the poor, old compressor in this freezer had had a hard life due to an incorrectly wired thermostat. Hopefully, it will now last many more years and in the meantime, I have a spare thermostat!

the comment that it wouldn't turn on

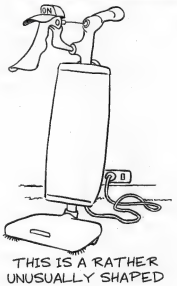
Because it only cost around $100, they had simply purchased a new one and if I didn't want the faulty unit, it would go to the dump. However, I decided that it would be well worthwhile taking a look at it, as the fault was probably something simple. What's more, it was still in pretty good condition overall, so if it could be repaired, it would be quite useful.

The first challenge was to determine how to dismantle it. It was hard to know where to start but removing some 20 screws soon had the unit broken down into about 12 separate pieces and I was able to access the motor. I checked the brushes and found that they were almost like new, so no worries there.

Next, I turned my attention to the power switch, as this was now the most likely cause of the problem. To test it, I simply disconnected the two leads that ran to it and connected them together. I then plugged the cord in, applied power and quickly switched off again when the motor fired up. This confirmed that the motor was in good working order and that the switch was indeed the culprit.

The next challenge was to remove the switch. It was obviously inserted from the top but there was a spring-loaded button on the outside of the casing and there was no obvious way to remove it. In the end, I slid a thin knife blade up the side of the switch button, while holding the top. The button then came off and revealed a spring and a retainer which held the switch in. After undoing the two screws in this retainer, I had the switch in my hand.

This is a rather unusually-shaped switch and would be difficult to source as a spare part, so I carefully and slowly prised the two small retaining clips up and gently lifted the top of the switch off. Inside, I found a spring and a small arm, which had a contact at one and and a raised bend at the other end which sat in a hollow



THIS IS A RATHER UNUSUALLY SHAPED SWITCH

section of the connector at the bottom of the switch.

The reason for the switch failing to work was obvious. A thick insulating

continued on page 103

Low-cost precis 10V DC referenc checking DMMs

Ever checked the calibration of your digital multimeter? OK, we know . . . you haven't because there's no easy or cheap way of doing it. But now you can, with this low-cost precision DC voltage reference. Without any adjustment it will provide you with a source of 10.000V DC accurate to within ±5mV or ±0.05%.

By JIM ROWE

MOST OF US DON'T ever get our DMMs calibrated, though we know that they do drift out of calibration over years of use. However, if you are using them during the course of your work, they should be checked every year or so – otherwise how can you trust the readings?

The problem is, it can cost quite a lot to send a DMM away to a standards lab for calibration – more than many DMMs are worth. So generally we either hope for the best or simply buy a new DMM if we suspect that our existing meter has drifted too far out of calibration.

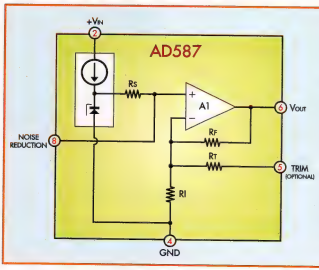
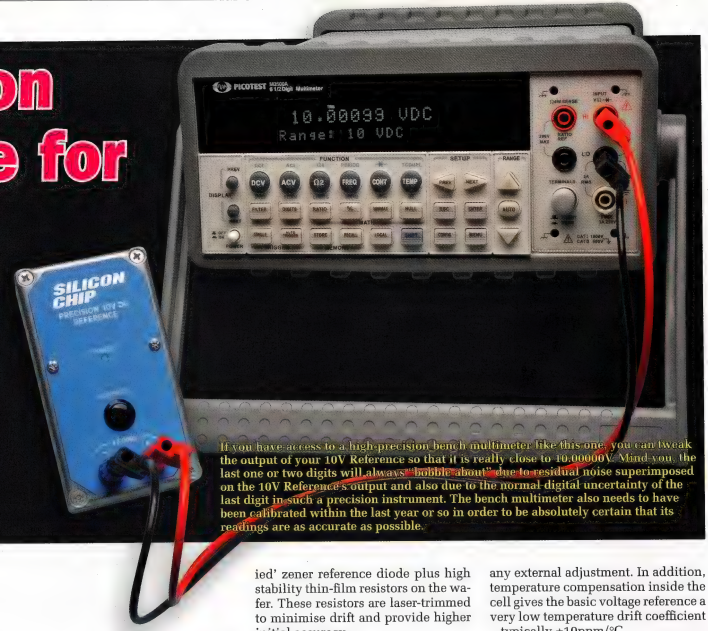


Fig.1: block diagram of the AD587 10V voltage reference. It consists of a buried zener diode and its associated current source, plus op amp IC1 which operates as an adjustable gain buffer stage. Buried zeners have their avalanche zone several µm inside the oxide layer and so do not suffer from long-term drift or 'walkout'.

Back in the 1970s, when DMMs first became available, the only practical DC voltage reference was still the Weston cell. This wet chemical 'primary cell' had been developed in 1893 and subsequently became the international standard for EMF/voltage in 1911. It produced an accurate 1.0183V reference which could be used to calibrate DMMs and other instruments.

Unfortunately, Weston cells were fairly expensive and few technicians had direct access to one for meter calibration. As a result, a reasonably-fresh mercury cell was often used as a kind of 'poor man's' voltage reference. Fresh mercury cells have a terminal voltage very close to 1.3566V at 20°C and the voltage falls quite slowly to about 1.3524V after a year or so. Silver oxide cells were also used for the same purpose, having a stable terminal voltage very close to 1.55V.

Of course, batteries have a tendency to obey 'Murphy's Law' and usually turn out to have quietly expired just before you need them. And although



If you have access to a high-precision bench multimeter, like this one, you can tweak the output of your 10V Reference so that it is really close to 10.00000V. Mind you, the last one or two digits will always "bobble about" due to residual noise superimposed on the 10V Reference's output and also due to the normal digital uncertainty of the last digit in such a precision instrument. The bench multimeter also needs to have been calibrated within the last year or so in order to be absolutely certain that its readings are as accurate as possible.

mercury and silver oxide cells have quite a long life, especially if you use them purely as a voltage reference, they certainly aren't immune to this problem. So these batteries make a pretty flaky voltage reference, at best.

Fortunately, in the 1980s, semiconductor makers developed a relatively low-cost source of stable and accurate DC voltage: the monolithic voltage reference (MVR). This is basically a very accurate voltage regulator. It produces a precise regulated DC output voltage when fed with unregulated DC power but unlike the more familiar 3-terminal regulators, it can supply very little current.

The Analog Devices AD587 device used in this new Precision 10V Reference Mk.2 incorporates a number of recent advances in MVR technology. These include an ion-implanted 'buried' zener reference diode plus high stability thin-film resistors on the wafer. These resistors are laser-trimmed to minimise drift and provide higher initial accuracy.

The AD587 also operates from an unregulated input voltage of between +15V and +18V, with a quiescent current of just 4mA. This is somewhat lower than earlier MVRs, making it very suitable for battery-powered operation.

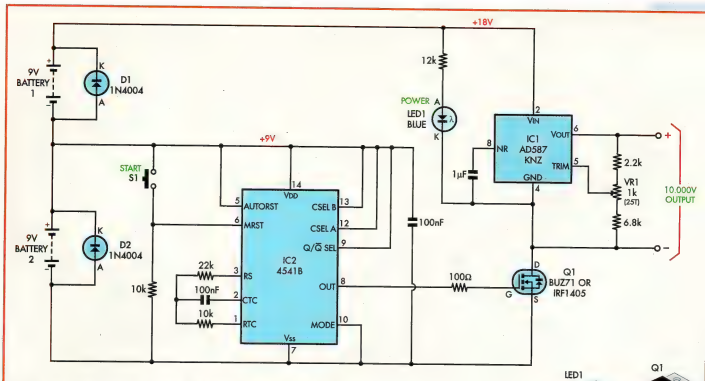
Block diagram

Fig.1 shows what's inside an AD587. The voltage reference cell itself is at upper left, consisting of the 'buried' zener and its current source.

The other main circuit section is op amp A1, used as an adjustable gain buffer. R_F, R_I & R_T are high-stability thin-film resistors, laser trimmed to allow the gain of A1 to be set with a high degree of precision. The output voltage (between pins V_{OUT} and GND) is initially set to 10.000V ±5mV for the AD587KNZ version used here, without any external adjustment. In addition, temperature compensation inside the cell gives the basic voltage reference a very low temperature drift coefficient – typically ±10ppm/°C.

Note that a slightly lower-spec version of the AD587 is also available, the AD587JNZ. This offers an initial (untrimmed) DC output voltage of 10.000V ±10mV, with a temperature drift coefficient of ±20ppm/°C. So you could use it as an 'almost as good' alternative if the KNZ version becomes unavailable.

Although the 'untrimmed' initial accuracy of the AD587KNZ (10.0V ±0.05%) is good enough for calibrating most low-cost DMMs, the chip can also be easily trimmed to improve its accuracy by a factor of greater than 10 times, ie, to around ±0.002%. This is done by connecting its TRIM pin (pin 5) to a trimpot circuit, connected between the V_{OUT} and GND terminals. This allows the gain of A1 to be adjusted to give an output anywhere within the range 9.900V to 10.300V,



SC PRECISION 10V REFERENCE MK2

Fig.2: the complete circuit diagram. IC1 is the precision 10V reference, while IC2 operates as a 90s timeout counter. When S1 is pressed, IC2 turns Mosfet Q1 on for 90s and connects IC1 and LED1 across the 18V supply.

with no adverse effect on temperature stability.

If this trim adjustment range seems a little wide, this has been done deliberately to provide the option of setting the output voltage to 10.240V. It can then be used as a reference source for binary DACs and ADCs (more about this later).

The 400mV adjustment range does mean that in order to accurately set the output voltage, we have to use a 25-turn trimpot in series with two fixed resistors. And of course, in order to take advantage of this trimming feature, you really need access to an even higher precision voltage reference to compare it with. Either that, or access to a recently calibrated high-resolution DMM.

Circuit details

Refer now to Fig.2 for the complete circuit details. There's not a lot to it – just the AD587KNZ precision voltage reference (IC1) plus some extra circuitry to allow the AD587KNZ to run from two 9V alkaline batteries to provide a truly portable reference.

This additional circuitry is based around IC2, a programmable CMOS timer. It provides a 90-second timeout function and controls IC1's operation via Q1, a BUZ71 (or IRF1405) N-channel Mosfet.

IC2 (4541B) is basically a binary counter with 16 stages. It can be configured as either an 8, 10, 13 or 16-stage counter by changing the logic levels to which its two 'CSEL' programming inputs (pins 12 & 13) are connected. In this circuit, both these inputs have been connected to +9V (ie, tied high), to configure the counter to use its full 16 stages.

The 4541B also contains its own clock oscillator, the frequency of which is set by the RC timing components connected to pins 1, 2 & 3. In this case, the values specified give an overall timer period of around 85-90 seconds.

IC2's output at pin 8 drives Mosfet Q1's gate via a 100Ω resistor. As a result, each time pushbutton switch S1 is pressed (and resets the counter), pin 8 of IC2 goes high and Q1 turns on and connects IC1 across the 18V supply for the duration of the 85-90s timing period. At the end of this period, pin 8 switches low and Q1 turns off to remove power from IC1 and conserve battery life.

Pressing S1 again starts the timing period all over again, if further calibration checks are necessary.

Power comes from the two 9V batteries, while D1 & D2 act as voltage clamps to provide reverse polarity protection if a battery is connected the wrong way around. LED1 and its associated 12kΩ current limiting resistor are connected across IC1's supply pins, so the LED functions as a power-on indicator. Using a high-efficiency 3mm blue LED gives a very visible indication while adding less than 1.5mA to the total current drain.

By the way, you may be wondering why we have used a BUZ71 or IRF1405 power Mosfet for Q1 when IC1 and LED1 only draw a maximum of 16mA or so, even with a 10mA external load (the maximum current the AD587 can provide). This is because the BUZ71 (or IRF1405) offers a much lower on-resistance than smaller low-power Mosfets like the 2N7000. This provides a much lower voltage drop and allows us to achieve significantly longer life from the 9V batteries.

The connections for IC1 itself are easy to follow. The 1µF capacitor connected between pin 8 (NR) and pin 4

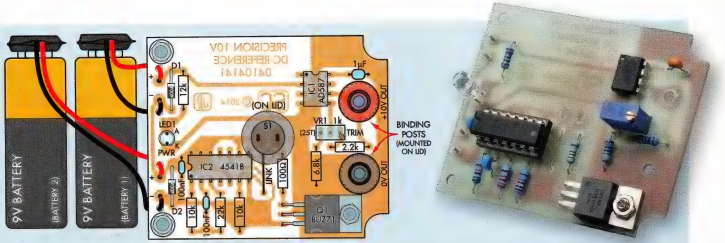


Fig.3: follow this layout diagram build the unit but note that switch S1 and the two binding post terminals are soldered to the PCB only after they have been mounted on the case lid (see text). Leave out trimpot VR1 and the 2.2kΩ and 6.8kΩ resistors if you don't intend calibrating the unit. Note: the prototype PCB shown in the photo lacks the reverse-polarity protection diodes and the strain relief holes for the battery leads included in the final version.

(GND) is there to provide additional low-pass filtering of any noise generated by the AD587's buried zener. It works in conjunction with series resistor R_S, which is shown in Fig.1.

Trimpot VR1 and its two range setting resistors are for 'trimming' the output voltage of IC1 to the desired 10.000V or 10.240V. However, note that there's no point in fitting these parts unless you have access to a very accurately-calibrated DMM, to compare it against while you're doing the trimming adjustment. **In fact, these parts must be left out if you have no way of performing the calibration, otherwise they will upset the accuracy.**

Conversely, if you are able to carry out calibration, the resistor values shown (2.2kΩ & 6.8kΩ) will give a trimming range centred on 10.000V. Alternatively, if you want the trimming range to be centred on 10.240V, change the 2.2kΩ 'upper' resistor to 8.2kΩ and change the 6.8kΩ 'lower' resistor to 1.0kΩ.

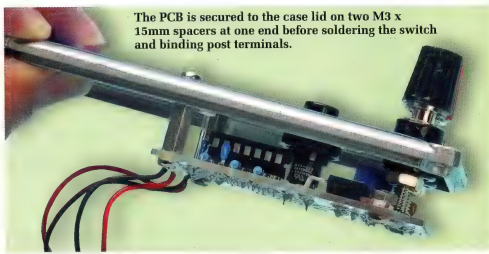
In both cases trimpot VR1 should have a value of 1kΩ as shown, and should be of the 25-turn cermet type.

Construction

Building the Precision 10V Reference Mk.2 is easy. All parts except for the binding post output terminals, switch S1 and the two 9V alkaline batteries are mounted on a single PCB coded 04104141 and measuring 63 x 53mm. This board fits inside a diecast aluminium box measuring 111 x 60 x 30mm, which not only protects the assembly but also provides shielding.

Fig.3 shows the parts layout on the PCB. Note that although trimpot VR1 and its series resistors are shown here, these parts are optional and should only be installed if you can calibrate the device (as mentioned earlier).

Begin the assembly by installing the wire link, then fit the five fixed resistors on the lefthand side of the PCB, plus the two series resistors for trimpot VR1 if it's being used. That done, fit the three multilayer ceramic capacitors, making sure that the 1μF



The PCB is secured to the case lid on two M3 x 15mm spacers at one end before soldering the switch and binding post terminals.

Table 2: Capacitor Codes

Value	μF Value	IEC Code	EIA Code
1μF	1μF	1u0	105
100nF	0.1μF	100n	104

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	22kΩ	red red orange brown	red red black red brown
❑	1	12kΩ	brown red orange brown	brown red black red brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	1	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	1	100Ω	brown black brown brown	brown black black black brown

Parts List

1 diecast aluminium case, 111 x 60 x 30mm (Jaycar HB-5062 or similar)
1 PCB, code 04104141, 63 x 53mm
1 front-panel label
1 SPST panel-mount momentary pushbutton switch (S1)
1 14-pin DIL IC socket (optional)
1 red binding post terminal
1 black binding post terminal
2 M3 x 15mm tapped spacers
5 M3 x 6mm machine screws
1 M3 hex nut
1 M3 shakeproof washer
2 9V battery clip leads
2 9V alkaline batteries
1 1kΩ cermet trimpot, 25-turn vertical (VR1)
1 100mm length double-sided tape

Semiconductors

1 AD587KNZ or AD587JNZ 10V voltage reference (IC1)
1 4541B programmable CMOS timer (IC2)
1 BUZ71 or IRF1405 Mosfet (Q1)
2 1N4004 diodes (D1, D2)
1 3mm high-intensity blue LED (LED1)

Capacitors

1 1μF multilayer ceramic
2 100nF multilayer ceramic

Resistors (0.25W, 1%)

1 22kΩ
1 12kΩ
2 10kΩ
1 6.8kΩ (or 1kΩ for 10.240V output)
1 2.2kΩ (or 8.2kΩ for 10.240V output)
1 100Ω

capacitor goes in at top right.

Now for the two ICs. IC1 must be soldered directly into the board, to ensure reliability (and avoid possible contact resistance). IC2, on the other hand, can either be soldered directly to the PCB or can be installed via a 14-pin DIL socket. Make sure that both ICs are correctly orientated.

Trimpot VR1 is next on the list, followed by Mosfet Q1. Note that Q1's leads must be bent down through 90° about 5mm from its body before mounting it in place. Push it all the way down so that its metal tab sits flush against the PCB and secure it using an M3 x 6mm machine screw, nut and shakeproof washer.

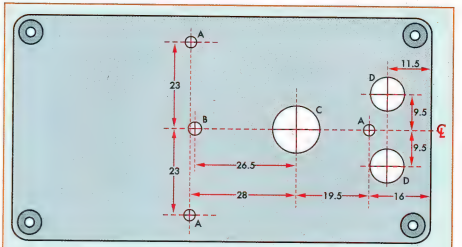


Fig.4: this diagram shows the drilling template for the front panel. It can either be copied or downloaded from the SILICON CHIP website.

Do the screw up firmly, then solder the Mosfets leads to their respective pads (note: don't solder the leads first, otherwise the PCB tracks will crack as the mounting screw is tightened down).

LED1 can now be installed, making sure its longer anode (A) lead is orientated as shown. It should be mounted about 7mm proud of the PCB (use a cardboard spacer). Solder just one lead and don't trim the leads at this stage, as you may have to adjust its height later, after the PCB assembly has been mounted on the rear of the lid.

Next, pass the four battery snap leads through the strain-relief holes and solder them to the PCB. That done, cover these connections with silicone to prevent the leads from breaking.

Be sure to connect the red wire from each battery snap to the pad marked '+'.

Your PCB assembly will now be finished and can be placed aside while you prepare the case – or strictly, the case lid since there are no holes to be drilled in the case itself.

Drilling the case lid

Fig.4 shows the drilling template for the case lid. You have to drill/ream seven holes in all – for the output terminals, switch S1, power LED and PCB mounting, plus a screwdriver access hole for trimpot VR1 (if necessary).

Fig.4 shows the location and size of each of these holes. You can either follow this diagram to mark out the lid for drilling or you can copy it, cut it to size and attach it directly to the lid (using double-sided tape) for use as a drilling template. The drilling template is also available for download from our website (free for subscribers).

Use a small pilot drill to start the holes, then remove the template and carefully drill and ream them to size. Deburr each hole with an oversize drill or in the case of the three larger holes, a small rat-tail file.

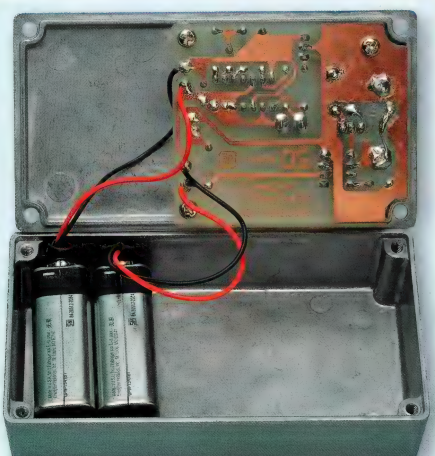
Now for the front panel artwork. This artwork can be obtained either by photocopying Fig.5 onto an adhesive-backed label or it can be downloaded as a PDF file from the SILICON CHIP website (again, free for subscribers) and printed out. It can then be covered with a self-adhesive transparent film to protect it from finger marks.

Alternatively, it can be photocopied onto plain paper, hot-laminated into a clear protective sleeve and then attached to the lid using double-side tape or silicone adhesive. The various holes can then be cut out using a sharp hobby knife.

Pushbutton switch S1 can now be mounted on the lid, taking care to orientate it so that its two connection lugs are aligned along the long axis. This is necessary so they will later fit through their holes in the centre of the PCB. That done, attach the two output terminals (binding posts) to the lid, making sure that the red terminal goes to the '+' position and the black terminal to the '-' position.

Specifications

- Output voltage: 10.000V DC (10.240V optional — see text)
- Basic accuracy: ±0.05% (±5mV) without adjustment, ±0.002% after trim adjustment
- Long term drift: <15ppm per 1000 hours, mostly in first year of operation
- Temperature stability: <7mV change between 0°C and +70°C
- Maximum output current: 10mA
- Noise on output: <4µV peak-to-peak (0.1Hz – 10Hz); <180µV peak-to-peak (DC – 1MHz)
- Load regulation: less than ±100µV/mA for loads up to 10mA
- Power supply: 2 x 9V alkaline batteries; quiescent current drain (when operating) <6.5mA
- Auto-off time: 90 seconds; standby current 10nA



This is the view inside the completed unit. The two 9V batteries are held together and to the bottom of the case using double-sided adhesive tape.

Tighten the mounting nuts of the terminals as firmly as possible, so that they're held securely in place.

Final assembly

As shown in the photos, the PCB mounts on the back of the lid and is supported by two M3 x 15mm tapped spacers at one end and by the two output terminal connections at the other.

The first step is to fit the two M3 x 15mm spacers to the 'battery end' of the PCB. That done, the PCB can be fitted in place, making sure that (1) both switch lugs pass through their matching holes; (2) LED1 passes up

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SKU:RLD-128 **Price:$109.95+GST**

DIN Rail Power Supply
120 W Slim High Efficiency DIN Rail Power Supply takes 88 to 264 VAC / 124 to 370 VDC input and gives 24 VDC out at up to 5 A. Power in and out are connected via screw terminals. A trimpot allows the output voltage to be adjusted approximately ±10%.
SKU:PSM-251 **Price:$129.60+GST**

Programmable Bar Graph Display
Universal linear input, DIN rail mount programmable tri-colour LED bar graph unit. Programmable 3 digit display with 1 x SPDT relay output. 12 to 24 VDC/AC powered.
SKU:CMC-030 **Price:$259+GST**

Site-Log Programmable Datalogger
LPVB-1 is an 7-channel, stand alone programmable voltage data logger, which records up to 4Mb of data and stores it in non-volatile flash memory for later retrieval. DIN rail mount and housed in an alumium enclosure. Battery life up to 10 years.
SKU:MED-001 **Price:$549.00+GST**

For OEM/Wholesale prices
Contact Ocean Controls
Ph: (03) 9782 5882
oceancontrols.com.au

Device Availability

Analog Devices make 18 different versions of the AD587, many of them in small outline (SOIC) SMD plastic or CERDIP packages. By contrast, the AD587KNZ and AD587JNZ both come in 8-pin PDIP packages and are quite reasonably priced.

Both are currently available in Australia from suppliers such as element14 and RS Components. For example element14 (au.element14.com) has the AD587KNZ (order code 2143134) available for $13.57 plus GST, while the lower-spec AD587JNZ (order code 9605169) costs $9.57 plus GST.

Similarly, RS Components (australia.rs-online.com) sells the AD587KNZ (order code 523-7415) for $9.38 plus GST, while the AD587JNZ (order code 412-579) is actually slightly more at $9.58 plus GST.

You shouldn't have any trouble getting the 4541B programmable timer, either. For example, element14 has it (order code 1106124) for less than $1.00.

through its corresponding hole in the lid; and (3) the binding post spigots pass down through their matching holes in the PCB. The PCB can then be fastened in position using two more M3 x 6mm machine screws which pass through the lid and into the spacers.

Once it's in place, the switch lugs and binding post spigots can be soldered to their respective PCB pads. If necessary, the solder connection on the LED lead can then be melted and the LED adjusted so that it just protrudes through its front-panel mounting hole. The remaining LED lead can then be soldered and the first lead then redone with some fresh solder.

Finally, the battery snap leads can be fitted to a pair of new 9V alkaline batteries, after which the batteries can be held together using a strip of double-sided adhesive tape between them. Two more strips of double-sided tape are then used to secure the batteries to the bottom of the case, after which the lid/PCB assembly can be fitted and the lid fastened down using the four countersunk M4 screws supplied.

That's it – your Precision 10V DC Reference Mk.2 is complete. Now for the smoke test.

Using it

There are no adjustments to be made to the unit, unless (as previously stated) you have access to a high-precision, recently-calibrated DMM to calibrate it against. If you're not calibrating the unit, you will be relying on the ±5mV or better precision provided by the AD587KNZ chip itself. In that case, check that trimpot VR1 and/or its two associated resistors have been left out of circuit, otherwise the accuracy of the unit will be compromised.

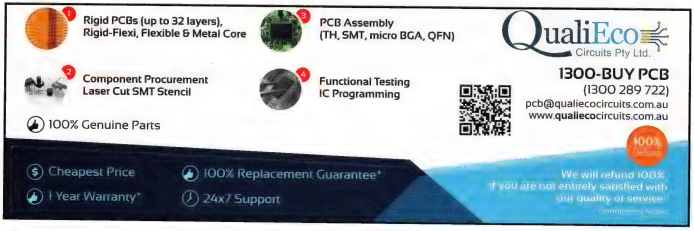
Using the Precision 10V Reference is simple – just press S1 to turn the the unit on for about 90s. As soon as you press S1, LED1 should light to show that the unit is operating and providing 10.000V ±5mV at its output terminals, ready for calibrating your DMM or whatever.

If you haven't finished making measurements when LED1 turns off (ie, when the unit unit powers down), it's simply a matter of pressing S1 again to power it up for another 90s.

Fig.5: this full-size front panel artwork can be laminated and attached using silicone adhesive or double-sided tape.

Incidentally, you'll find that when you first connect the battery snap leads to the batteries, LED1 will turn on to show that the unit is operating. This is normal and is simply due to the way that the 4541B timer chip works.

Finally, if you wish to calibrate the unit, make sure VR1 and its associated resistors have been installed. It's then just a matter of monitoring the output on a 6.5-digit (or better) bench DMM and adjusting VR1 to get a reading as close as possible to 10.00000V (or 10.24000V if you prefer). SC



MARCH EDITION

PRE CATALOGUE $AVINGS!

Prices valid until 23/03/2014

Online & in store

Solar Rechargeable LED Floodlight with Motion Sensor

A great way to light up a shed, workshop or garage without needing mains power. The LED light automatically turns on when darkness falls, and is activated when the PIR detects motion.

- 10W power, cool white
- 3W solar panel with 3m cable

SL-2808

NEW

$159.00

Powerboard with Mains Filter, Telephone, Video & TV Protection

Keep your home theatre equipment safe.

- 8 surge and spike protected outputs
- Data via a network connection
- Satellite/cable TV and TV aerials

MS-4024 **WAS $49.95**

$39.95

SAVE $10

HD Car Event Recorder with LCD

Watch recordings on the 2.5" colour LCD screen or on your TV. Includes cigarette lighter power cable, USB cable and suction mount bracket.

- 720p 5MP camera
- Motion detection
- Cycled recording mode
- JPG snapshot button
- HDMI output
- Built-in rechargeable Li-ion battery
- Requires microSD memory card

QV-3840 **WAS $149.00**

$119.00

SAVE $30

2.4GHz Digital Wireless Reversing Camera Kit

Digital signal provides clear video, better range and security. Simple installation, 12V power for camera, cigarette lighter socket power for monitor. All size vehicles. Add up to 4 cameras (sold separately) for increased visibility.

- 3.5" colour LCD
- 100m range

QM-3802 **WAS $249.00**

$199.00

SAVE $50

Spare camera QM-3803 WAS $149 NOW $79 SAVE $70

Watch this space... 2014 Catalogue OUT SOON!

Jaycar Electronics

Better, More Technical

EtherTen (Arduino Compatible Board)

Includes onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, and even Power-over-Ethernet support.

- ATmega328P MCU running at 16MHz
- 10/100base-T Ethernet built-in

XC-4216

$69.95

Multifunction Clock with Hidden Camera

Full function LCD clock with a hidden spy camera. Set it up in an area of concern and it will detect motion then commence recording. 720p. AVI format. 4GB microSD card included (capable of taking a maximum of 32GB).

- 1280 x 720 image capture
- 12 hour recording time

QC-8026

NEW

$119.00

HDMI Over Cat 5 Extender

Extend your HDMI signal up to 60m using CAT5/6 cables. Fully HDCP compliant. Built-in infrared extender. See website for full details.

AC-1689 **WAS $169.00**

$149.00

SAVE $20

NEW STORE

Modbury SA

Visit our NEW premises

952 North East Rd SA 5092

ph: 1800 022 888

5.8GHz Wireless AV Transmitter and Receiver

Transmits audio/video signals up to 50m clear line of sight. Compatible with most PayTV systems and AV equipment. Built-in infrared extender. Power supplies and AV cables included.

AR-1878 **WAS $99.00**

$89.00

SAVE $10

2.4GHz Digital Wireless Headphones

Stylish wireless headphones with a digital TOSLINK audio input to connect your digital devices such as home theatre system, gaming consoles, CD and DVD players.

- Built-in rechargeable battery
- Built-in FM radio
- Up to 50m range under optimal conditions

AA-2086

NEW

$99.00

900MHz version also available

AA-2083 $79.95

Night Vision Monocular

Monocular scope with integrated infrared illuminator for observing in total darkness. 3 x magnification. Tough housing. Ideal for viewing wildlife at night, security personnel etc.

- Max range: 150-200m (2-10 Lux)

GG-2129

$249.00

To order call 1800 022 888

www.jaycar.com.au

Jaycar Electronics
Better. More Technical.

TEST & MEASURE

Cat III True RMS Autoranging DMM with Temperature

Non-contact voltage testing. Backlit LCD. Leads, carrying pouch and k-type thermocouple included.

- 4000 count
- Foldout stand
- Powered by 1 x 9V battery (included)

QM-1551 **$59.95**

400 Amp Stainless Steel Battery Clamps

All metal parts are made from 316 marine grade stainless steel and can be taken and used anywhere without the risk of corrosion. Rated 400A.

- Sold as a pair

HM-3086
WAS $12.95

$9.95
SAVE $3

Jumper Leads Set

Each lead is 155m long. Can be installed on a 0.1" header. Use in ARDUINO projects, school experiments, or RC and other hobbyist activities.

- 10-pce

NEW

Mixed Plug to Socket/Socket to Socket - WC-6021 $3.95

Plug to Plug - WC-6022 $3.95

$3.95 EA

TESTERS with SMARTPHONE APP

Professional Laser Distance Meter with Smartphone App

Measure distance, area, and volume. Store the last 20 measurements for easy comparison and referral. Paired with a Smartphone to email measurements with a picture or upload to the Cloud.

QM-1624 **$209.00**

Free Digitech LDM app available from the App Store and Google Play

IP67 True RMS DMM with Smartphone App

View live measurements, trend graphs, data log, email your results and upload them to the Cloud - all from your Smartphone! Just connect this unit to your Smartphone and use the free Digitech DMM app and away you go.

- IP67 waterproof
- Bluetooth® Smartphone/PC interface
- Data log storage
- 10A current range

QM-1576

NEW

Free Digitech LDM app available from the App Store and Google Play

$219.00

Plug-In Type USB Datalogger

Log temperature and humidity readings. Download to PC via USB.

$119.00

- 32,000 memory samples

QP-6013

USB / LCD Readout Type also available QP-6014 $179.00

Wind Speed Meter/Thermometer

Capable of measuring wind/airflow parameters at the same time as monitoring temperature. Auto power off.

- Metres/sec; km/hr; feet/min; miles-per-hour; knots
- Cubic metres/minute; cubic feet/minute
- Air temp, 0-50°C (0.1°C resolution)

QM-1646 **$99.00**

3 in 1 Stud Detector with LCD Screen

Survey your wall with ease by sliding this handheld detector along the surface. With three modes to sense: studs, cables, and metal, this handy device allows you to locate and mark items hidden within a wall.

- Automatic calibration
- Requires 9V battery

QP-2283 **$24.95**

Economy Non-Contact Thermometer

Safely measure temperature in hot, hazardous, or hard to reach places with the built-in laser pointer directed at the surface.

- 8:1 Distance to spot ratio
- Auto data hold
- Carry case included

QM-7215 **$39.95**
WAS $49.95 **SAVE $10**

Compact Digital Sound Level Meter

Measures sound levels between 30 to 130dB and can be set for fast or slow responses. Data hold. Min/ max function. Backlit LCD. Supplied with carry case, wind sock and battery.

- 3.5 digit display
- 30 to 130dB
- 210mm long

QM-1589 **$99.00**

1MHz Velleman Handheld Function Generator

A bench top generator in a portable size! Produces sine, square, and triangle waveform signals with output frequency adjustment from 1Hz to 1MHz with maximum amplitude of 8Vpp. See website for specifications.

- Backlit LCD
- Built-in rechargeable battery

QT-2304 **$199.00**

10MHz Velleman Rechargeable Handheld Pocket Scope

Complete portable oscilloscope! Aside from standard scope features, it has nifty tools for measurement of RMS speaker power, display hold function, and memory storage for 2 signals. Housed in a durable rubber surround. See website for full specifications.

$229.00
SAVE $20

- Backlit LCD
- Built-in rechargeable battery
- CRO probe and USB charge cable supplied

QC-1914 **WAS $249.00** PCB not included

DIY TOOLS

Jaycar Electronics
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Electric Screwdriver Kit

Powerful X torque electric driver with massive 102-piece stainless steel bits packed in a tough aluminium carry case.
TD-2491

$39.95

Universal Drill Press Stand

Convert your standard power drill or rotary tool into a drill press with this adjustable stand. Built-in press depth gauge for accurate drilling. Metal base.

- Drilling depth: Up to 60mm

TD-2463

$29.95

Rotary Tool Kit

Powerful 32,000 RPM rotary tool that you can use with numerous attachments. 1m long flexible shaft. Suitable for model making, automotive, workshop, art, jewellery or sculpture. See website for full contents.

- 135W

TD-2459

$39.95

Large Glue Gun

Fast, easy to use with trigger controlled glue feed to repair many household materials. Supplied with 2 glue sticks.

- Mains powered
- 100W

TH-1999

Pack of 6 Glue Sticks also available TH-1995 $4.95

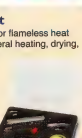
$14.95

Adel Nibbling Tool

Cut, notch or trim simple or complex shaped holes in plastics, laminates, leather or metal. Ideal for chassis-bashing and all sorts of hobby applications.

- USA made

TH-1765



$69.95

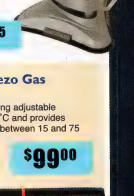
Spare punch TH-1767 $29.95

Vacuum Bench Vice

Suited to small bench jobs such as model building, jewellery making and general PCB/chassis work.

- Vacuum base
- Ball joint clamp
- 75mm opening jaw with removable soft rubber jaw covers.

TH-1766



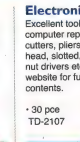
$29.95

Upright Gas Torch

Versatile and ideal for silver soldering, jewellery work, plumbing, brazing or general hobby use. Easily filled with butane gas (sold separately).

- Piezo ignition with safety lock
- 1300˚C adjustable flame

TS-1660



150g Butane Gas NA-1020 $5.95

$39.95

Gas Soldering Tool Set

Handy soldering iron with flame or flameless heat blower function, suitable for general heating, drying, melting, cutting, soldering, heat shrinking etc.

- Adjustable temperature control
- Flame temp: Up to 1300˚C
- Power range: 25W to 70W

TH-1606

$44.95

portasol® Pro Piezo Gas Soldering Iron

Powerful soldering iron featuring adjustable temperature control up to 580˚C and provides equivalent electrical power of between 15 and 75 watts. Supplied with a 2.4mm double flat tip.

- Internal Piezo crystal igniter

TS-1310

$99.00

The Power Driver Bit Set

Undo those tricky security screws with this useful bit set. See website for full contents.

- 32 pce

TD-2035

$12.50

Electronic Tool Kit

Excellent tool kit for electronic or computer repairs with all the essentials - cutters, pliers, screwdrivers (Phillips head, slotted, Posidrive), nut drivers etc. See website for full contents.

- 30 pce

TD-2107

$29.95

Long Bit Screwdriver Set with Case

Selection of popular slotted, Phillips, Star and TRI bits packed neatly inside a handy storage case. See website for contents.

- 22 pce

TD-2114

$29.95

Mini Tap & Die Set

Consists of 9 metric screw cutting dies and 18 equivalent taps in the same sizes. For the ultra small screws found in electronics.

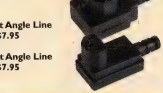
- 31 pce

TD-2443

WAS $59.95

$49.95

SAVE $10



IP66 ABS Enclosures

Gasket seals, stainless steel hardware and IP66 rated for use in industrial, marine and other harsh environments.

- Lockable

FROM $29.95

SAVE $5

Opaque HB-6404 (shown)
WAS $34.95 NOW $29.95
SAVE $5.00

Transparent HB-6412
WAS $32.95 NOW $29.95
SAVE $3.00

CONNECTORS

F-81 Inline Joiner - Foxtel Approved

- Socket to Socket
- Foxtel Approved

PP-0648

NEW

$4.95

Right Angle IEC Adaptors

For installations where wall space or rack space is extremely limited. Both units feature strain relief rubber cable entries.

IEC320 C13 Right Angle Line Plug PP-4012 $7.95

IEC320 C14 Right Angle Line Socket PS-4015 $7.95

NEW

$7.95 EA

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PRE-CATALOGUE SALE

AUTOMOTIVE

12VDC 5 in 1 Tester

Passive, quick and easy testing solution that performs five essential tests in the field: voltage, load, polarity, voltage drop and continuity. Ideal for CCTV and security installers, car audio, roadies, AV techs etc.

QP-2215 **WAS $14.95**

$9.95 **SAVE $5**

Brake Fluid Tester

Determines brake fluid quality by testing the percentage of water in the brake fluid.

- Includes 1 x AA battery
- Size: 150mm long

QP-2291 **WAS $29.95**

$24.95 **SAVE $5**

Digital Tyre Pressure Gauge

Measures pressure from 5 to 100PSI and includes an integrated torch for night time use.

- Includes 2 x AAA batteries
- Size: 156mm long

QP-2293 **WAS $14.95**

$9.95 **SAVE $5**

7" TFT Colour Monitor with Headrest

Excellent addition to your in-car entertainment system. Features a 7" TFT screen, two composite video inputs and IR remote control.

- Resolution: 1440 x 234 (16:9/4:3 selectable)
- System: NTSC/PAL
- Power: 12VDC
- Dark grey leather-look upholstery

QM-3773 **WAS $149.00**

$99.00 **SAVE $50**

In-Store Only. Limited Stock. Not Available Online

"Black Box" Car Multifunction Unit

Features a built-in camera to record vision through the windscreen as you drive, MP3 player and FM radio, GPS navigation function*. Supports microSD and MMC cards.

- 5" touch screen LCD
- Built-in GPS antenna
- 3.5mm Stereo Audio output

QV-3812 **WAS $149.00**

$119.00 **SAVE $30**

*Note: Mapping software not included but can be purchased directly online. See website for more info.

3W Head Torch

Conquer a variety of outdoor trails at night with this 3W CREE® LED powered multi-function head torch. Three light modes (high, dim, strobe). Built-in tail light. Rechargeable Li-ion battery.

- 100 lumens

ST-3297 **WAS $39.95**

$29.95 **SAVE $10**

Limited Stock.

Strobe LED Lights

This portable LED flashing strobe light, has a magnetic base which can be placed on any iron/steel surface. Battery operated.

- Requires 3 x AAA batteries

Red	**SL-3325**	**WAS $19.95**
Blue	**SL-3327**	**WAS $19.95**
Amber	**SL-3329**	**WAS $19.95**

$14.95 ea **SAVE $5**

Rechargeable Automotive Work Light

A functional 200 lumen work light no motor enthusiast should be without. Affix to any metallic surface via magnetic base and back. Use it like a torch or hang it off your car bonnet.

- 3 x 1W CREE® LEDs

ST-3261 **WAS $59.95**

$44.95 **SAVE $15**

Wireless Tyre Pressure Monitoring Kit

Track PSI data from the 4 sensors fitted to your tyres on the 12VDC monitor in your car. High and low pressure alarm.

- Suitable for vehicles designed for 30-42PSI

QP-2298 **WAS $199.00**

$159.00 **SAVE $40**

Weather Station with Clock & Photo Frame

Keep tabs on the weather and time or display photos. A remote sensor sends data to the display unit, which provides temperature, humidity, trend and forecast information and also displays indoor temperature. Mains plugpack included.

- 12/24 hour clock with alarm
- Wall or desk mount

XC-0345 **WAS $89.00**

$79.00 **SAVE $10**

OUTDOORS

3W LED Torch with Solar Charging Compartment

Powerful torch that can be charged from the solar compartment. Great for camping and long trips away from mains power. 150 lumens.

- LED indicators

ST-3469 **WAS $69.95**

$29.95 **SAVE $40**

Dynamo Torch with Radio, Clock & Alarm

Full clock & alarm functions, AM and FM radio, LED torch and reading lamp that can all be powered by manual hand crank (dynamo), batteries or external power supply.

ST-3352 **WAS $49.95**

$39.95 **SAVE $10**

Rechargeable Spotlight

247 lumen output. CREE® LED powered. Switchable between half and full power output. Battery status indicator, emergency SOS mode, flip-up work stand, robust ABS construction, mains and car chargers included.

ST-3309 **WAS $39.95**

$34.95 **SAVE $5**

1.3MP Sports Camera

Perfect for the next extreme adventure. Simple one-button operation to start and stop recording and uses SD cards (sold separately) up to 32GB for storage. Requires 2 x AAA batteries.

- 640 x 480 @ 30fps video resolution

QC-3238 **WAS $39.95**

$29.95 **SAVE $10**

To order call 1800 022 888

www.jaycar.com.au

Savings off original RRP. Limited stock on sale items

PRE-CATALOGUE SALE

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2.4GHz Intercom/Doorphone

Transmit crystal clear 2.4GHz signal up to 100m range. Compact and wireless. Mains charger included.

- Weatherproof outdoor unit AM-4332
  WAS $79.95

$59.95
SAVE $20

Wireless MP3 Doorbell

Plays your favourite MP3 song or message.

$39.95
SAVE $5

- Built-in 16 polyphonic sounds
- Up to 100m range
  LA-5024 **WAS $44.95**

2-Zone Alarm Kit

Simple two zone, two wire alarm for small to medium size premises. Additional sensors (sold separately) can be added if required.

$59.95
SAVE $10

- Includes: 2-Zone control unit, PIR sensor, Reed switch & 25m cable
  LA-5480 **WAS $69.95**

PIR Sensor
LA-5481 $24.95

Network 4 Channel DVR with 4 High Resolution CCD Cameras

View live and/or recorded footage anytime, anywhere! Contains multiplexing DVR with Ethernet access, four weatherproof CCD cameras with IR illumination and four 20m cables.

- H.264 video compression
- Motion trigger recording
- 500GB SATA Hard disk
- Weatherproof, 520TV line cameras
  QV-8108 **WAS $649.00**

$519.00
SAVE $130

In-store only. Limited stock. Not available online.

CAN'T DECIDE?
Give a JAYCAR Gift card

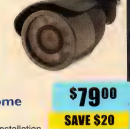
SURVEILLANCE CAMERAS

IP68 Camera with Concealed Cable Bracket

Equipped with IR LEDs that works in darkness with a 20 metre range.

- 380TV line
  QC-8611 **WAS $129.00**

$99.00
SAVE $30



2.4GHz Wireless Baby Monitor

Transmits 2.4GHz DIGITAL audio signal up to 50m transmission range. Plays music with five pre-programmed lullabies. Equipped with rechargeable docking station.

- Backlit LCD display screen
- Built-in mic and speaker
- Talk button key
  QC-3261
  WAS $69.95

$59.95
SAVE $10

USB Mini Inspection Camera

Use a laptop as a monitor to check for termites and other rodents, finding lost tools etc. 2 x LEDs for illumination.

- Mirror, magnet and hook included
- USB powered
  QC-3383 **WAS $39.95**

1.5m Flexible Cable model also available QC-3373 $39.95

$24.95
SAVE $15

3-Axis Colour Dome Camera

3-axis mechanism. Easy installation and enables you to put the camera's field of view exactly where required. Quality SONY® sensor.

- 550TV line
- CCD camera
  QC-8616 **WAS $99.00**

$79.00
SAVE $20

Solar Rechargeable Sensor Spotlight with Announcer

A simple method for adding a level of security in areas where no mains is available. Comes with a solar panel, sensor spotlight with PIR, and a wireless announcer.

- 500 lumens
- CREE® XML LED
- 100m range
  SL-3236
  WAS $129.00

$109.00
SAVE $20

Bullet Style CCD Camera

Weatherproof camera with 70° viewing angle. Panasonic CCD sensor. Adjustable mounting base and leads. Panasonic CCD sensor.

- 380TV line
- 12VDC
  QC-3488 **WAS $99.00**

$79.00
SAVE $20

Solar Wireless PIR Announcer

Monitor areas wirelessly with this solar wireless PIR motion detector. Easy to install. Mounting hardware included.

- Detection range 4-5m
- 2.4V rechargeable battery included
  LA-5174 **WAS $69.95**

$59.95
SAVE $10

Solar Charged Multi-Purpose LED Lamp

Doubles as a lantern or a pendant light. Charge the battery by connecting your lamp to the supplied solar panel.

- 100 lumens
  SL-2701
  WAS $39.95

$29.95
SAVE $10

Solar Powered Garage LED Light

Ideal for garages, gazebos and greenhouses. Swivel base for custom positioning. Weatherproof. Easy to install.

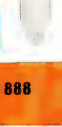
- Includes solar panel, mounting bracket, 2.4m cable and rechargeable enclosed Ni-Cd battery
  SL-2715 **WAS $34.95**

$24.95
SAVE $10

Rechargeable Spotlight with PIR Sensor

An emergency lighting solution suitable for hallways, entry and exit points. Acts as a standard PIR spotlight to illuminate paths when motion is detected.
SL-3232
WAS $64.95

$49.95
SAVE $15



Jaycar Electronics
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HARDCORE

Audio Cable

High quality OFC mono audio cable. Double screened for extra shielding.

- 100m roll length
- Sold per metre

WB-1508

$2.35/m

Self-Closing Braided Wrap

Protect cabling from abrasion, wear and tear using this flame resistant self closing wrap. 2m length. Flexible and lightweight.

FROM $6.95

6mm Dia.	WH-5630	$6.95
9mm Dia.	WH-5632	$7.95
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The easy way to connect 2 or 3 wires together. Simply insert into the connector and squeeze with a pair of pliers.

Pk8 (6 x 2 wire) and (2 x 3 wire) Connectors
HP-1214 $4.95

Pk50 2 Wire Connectors
HP-1270 $10.95

Pk50 3 Wire Connectors
HP-1272 $14.95

FROM $4.95

IP68 Cable Glands

These nickel plated brass cable glands are IP68 rated and are O-ring sealed against the ingress of dust, moisture and water to a depth of one metre.

FROM $7.45

3 to 6.5mm	HP-0744	$7.45
4 to 8mm	HP-0745	$7.95
5 to 10mm	HP-0746	$8.95
6 to 12mm	HP-0747	$9.45
10 to 14mm	HP-0748	$9.95

Thread Repair Kits

Enables you to drill out a stripped or otherwise damaged thread in a blind hole. Kit includes: drill bit, thread tap, insertion tool, tag punch and 10 inserts.

M3 Threads
HP-1600 $24.95

M4 Threads
HP-1602 $24.95

M5 Threads
HP-1604 $24.95

M6 Threads
HP-1606 $24.95

$24.95 EA

Quick Connect Crimp Connector Pack - 160 Pieces

Loads of connectors for automotive, marine & general purpose applications. Packaged in handy storage case. See website for contents.

- 160 pce

PT-4530

$22.95

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3 POLE + PE* 16A

PE Line Plug	PP-1006 $17.95
PE Line Skt	PS-1007 $17.95
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PE Chassis Skt	PS-1009 $12.95

6 POLE + PE* 10A

PE Line Plug	PP-1000 $19.95
PE Line Skt	PS-1001 $19.95
PE Chassis Plug	PP-1002 $13.95
PE Chassis Skt	PS-1003 $13.95

NOTE: *Pre-Engaging

FROM $12.95

HDMI ADAPTORS

Mini HDMI Plug to HDMI Socket Adaptor

PA-3645

$9.95

HDMI Plug to DVI-D Socket

PA-3642 $16.95

HDMI Socket to DVI-D Plug

PA-3644 $16.95

$16.95 EA

HDMI Socket to Socket Gender IC Adaptor

PA-3640

$16.95

Speakon Audio Leads

Speakon connectors are now the standard for PA and sound reinforcement applications. Excellent ready-made cable assemblies.

2 Core 5 metre	WA-7100	$24.95
2 Core 10 metre	WA-7102	$34.95
2 Core 15 metre	WA-7104	$69.95
4 Core 20 metre	WA-7106	$99.00

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AUDIO CONNECTORS

Slimline Gold Plugs

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PP-0132 $2.95

3.5mm 4-Pole
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Banana Sockets Binding Posts

- Metal

$4.95 EA

Red	PT-0430	$4.95
Black	PT-0431	$4.95

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- Gold Plated

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$5.95 EA

XLR Adaptors

- 3 pin adaptors

Male	PA-3684	$12.95
Female	PA-3686	$14.95

FROM $12.95

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433MHz Remote Switch Kit

Ref: Silicon Chip Magazine January 2009

Suitable for remote control of practically anything up to a range of 200m. The receiver has momentary or toggle output and the momentary period can be adjusted. Up to five receivers can be used in the same vicinity. Short-form kit contains two PCBs and all specified components.

$44.95

- PCB: Tx: 85 x 63mm; Rx: 79 x 48mm

KC-5473

Battery Saver Kit

Ref: Silicon Chip Magazine Sept 2013

Cuts off the power between the battery and load when the battery becomes flat to prevent the battery over-discharging and becoming damaged. Suitable for use with cordless power tools, emergency lights, small to medium UPS (up to about 300VA) and a wide variety of other devices.

- PCB: 34 x 18.5mm

KC-5523

$29.95

Theremin Synthesiser Kit MkII

Ref: Silicon Chip Magazine March 2009

Create your own eerie science fiction sound effects by simply moving your hand near the antenna. Easy to set up and build. Complete kit contains PCB with overlay, pre-machined case and all specified components.

$74.95

- PCB: 85 x 145mm

KC-5475

USB Power Monitor Kit

Ref: Silicon Chip Magazine Dec 2012

Plug this kit inline with a USB device to display the current that is drawn at any given time. Displays current, voltage or power. Auto-ranging and will read as low as a few microamps and up to over an amp. Kit supplied with double sided, solder masked and screen-printed PCB with SMD components pre-soldered, LCD screen, and components.

- PCB: 65 x 36mm

KC-5516

Laptop not included

$59.95

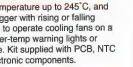
Economy Adjustable Temperature Switch Kit

Ref: High Performance Electronic Projects for Cars - Silicon Chip Publications

Adjustable switching temperature up to 245°C, and can be configured to trigger with rising or falling temperature. Also used to operate cooling fans on a radiator or amplifier, over-temp warning lights or alarms, and much more. Kit supplied with PCB, NTC Thermistor, and all electronic components.

- PCB: 105 x 60mm

KC-5381



$32.95

Ultrasonic Antifouling Kit for Boats

Ref: Silicon Chip Mag Sept/Oct 2010

Marine growth electronic antifouling systems can cost thousands. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in a sturdy polyurethane housings. Standard unit consists of control electronic kit and case, ultrasonic transducer, potting and gluing components and housings. The single transducer design of this kit is suitable for boats up to 10m (32ft); boats longer than about 14m will need two transducers and drivers. Basically all parts supplied in the project kit including wiring.

- 12VDC
- Suitable for power or sail
- Could be powered by a solar panel/wind generator
- PCB: 104 x 78mm

KC-5498

$249.00

Pre-built:

Dual output, suitable for vessels up to 14m (45ft) **YS-5600 $899.00**

Quad output, suitable for vessels up to 20m (65ft) **YS-5602 $1,199.00**

240V 10A Deluxe Motor Speed Controller Kit

Ref: Silicon Chip Magazine April 2009

Allows the speed of a 240VAC motor to be controlled smoothly from near zero to full speed. The advanced design provides improved speed regulation & low speed operation. Also features soft-start, interferences suppression, fuse protection and over-current protection. Kit supplied with all parts including pre-cut metal case.

$99.95

KC-5478

Note: Not for use with induction motors.

High-Power Class-D Audio Amplifier Kit

Refer: Silicon Chip Mag Nov/Dec 2012

High quality amplifier boasting 250WRMS output into 4 ohms, 150W into 8 ohms and can be bridged with a second kit for 450W into 8 ohms. High efficiency. Low distortion and noise. Over-current protection. Kit supplied with double sided, solder masked and screen-printed silk-screened PCB with SMD IC pre-soldered, heatsink, and electronic circuit board mounted components.

- Requires 57V/0/+57V power (sold separately)
- Optional speaker protection module (sold separately)
- PCB: 117 x 167mm

KC-5514

Accessories to suit: Stereo Speaker Protector Kit
KC-5515 $29.95
+/- 57V Power Supply Kit
KC-5517 $29.95

$89.95

Speed Control Kit for Induction Motors

Ref: Silicon Chip Mag April/May 2012

Control induction motors *up to 1.5kW (2HP) to run machinery at different speeds or controlling a pool pump to save money. Also works with 3-phase motors. Full form kit includes case, PCB, heatsink, cooling fan, hardware and electronics.

KC-5509

$249.00

*Does not work for motors with centrifugal switch

Mains Timer Kit for Fans and Lights

Ref: Silicon Chip Mag August 2012

This simple circuit provides a turn-off delay for a 230VAC light or a fan, such as a bathroom fan set to run for a short period after the switch has been tuned off. The circuit consumes no stand by power when load is off. Kit supplied with PCB, case and electronic components. See website for a list of alternate capacitors for different time periods.

- PCB: 60 x 76mm

KC-5512

$39.95

Jacob's Ladder MK3 Kit

Ref: Silicon Chip Magazine Feb 2013

A spectacular rising ladder of bright and noisy sparks for theatre special effects or to impress your friends. This improved circuit has even more zing and zap than it's previous design from April 2007 and requires the purchase of a VS Commodore 12V ignition coil (available from auto stores and parts recyclers). Powered from a 12V 7Ah SLA or 12V car battery.

- Kit supplied with silkscreened PCB, diecast enclosure (111 x 60 x 30mm), pre-programmed PIC, PCB mount components and pre-cut wire/ladder

KC-5520

Battery not included

$49.95

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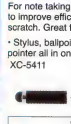

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Cadex C7400ER-C Battery Analyser

Review by Nicholas Vinen

This versatile unit can automatically charge, discharge, test, analyse and recondition virtually any type of battery pack. Up to four batteries can be connected at a time and many different types of connector are available, both for specific batteries and universal adaptors. The unit will quickly tell you whether an attached battery is good and if not, it will attempt to bring it back to full capacity.

The C7400ER-C is an automated battery charging, testing, analysing and exercising system. Each of its four bays can be filled with various kinds of interfaces to connect to battery packs for power tools, laptops, mobile phones and many other devices.

It can handle batteries up to 36V, 24Ah with a maximum charge or discharge rate of 6A per battery.

Lead-acid, Nicad, NiMH, Li-ion, Li-po or LiFePO4 batteries in any combination can be charged/analysed. All four connected batteries can be charged/discharged/tested simultaneously (within the unit's total power limits).

Who needs it?

We would envisage using a device such as this in one of two types of situation. First, by organisations or individuals who use a lot of batteries and need to keep them all charged and in top condition, ready for use.

Second, it could be used by those repairing, servicing or manufacturing batteries or battery-powered products. This unit will give you confidence that every battery going out the door is fully charged and functioning properly, with documentation to back that up. It will keep track of how a given battery's performance varies over time, with use. It's also a quick (and reliable) way to eliminate a dodgy battery as being the source of an equipment fault before a repair.

This unit is ideal for jobs like these since it can be configured for many different types of battery with minimal effort and can automatically determine whether a battery just needs to be charged or needs a more intense workout such as multi-cycle re-conditioning.

The C7400ER-C can be used as a standalone unit, controlled either manually on a per-battery basis or automatically, by simply plugging a battery into one of its adaptors. When set up for automated use, personnel with minimal training can connect a battery and the unit will let them know when it is ready for them to use, or if it needs replacement.

In this type of situation, the settings can be locked out so that users can't cause a malfunction or use the wrong charging profile for a battery. There are two security levels; one lets users select a profile to use for a given battery but not change any settings, while the higher password-protected security setting locks users into a particular profile for each adaptor/battery so they can't choose the wrong one.

This Battery Analyser can also be connected to a computer for more advanced diagnostics. In fact the software can handle over 100 units simultaneously for managing a large organisation which deals with a lot of batteries. It performs extensive logging to allow users to check the health of the organisation's batteries and also go back and look at when a given battery was serviced and what its condition was at the time.

Battery adaptors

The unit's four bays can be fitted with various adaptors to handle different battery types or they can all be the same, if your organisation only deals with one type.

Some of the adaptors can be "universal" types which can be used to connect to a variety of different types with a quick reconfiguration. Having said that, there are over 1000 custom adaptors available for just about any battery type imaginable.

Our photo shows the unit with a Makita power tool connector in its first bay, a general purpose banana plug/alligator clip interface with temperature sensor in its second bay (good for batteries with exposed tabs or terminals) and "RigidArm" and "FlexArm" adaptors in the other two bays.

These latter adaptors are used for rectangular or near-rectangular battery packs where the connectors are lands (ie, small rectangular pads), such as mobile phone batteries. For these, it's simply a matter of using the supplied magnetic brackets or spring-loaded slot to clamp the battery down onto the baseplate and then lower the spring-loaded arms down into contact with the battery terminals.

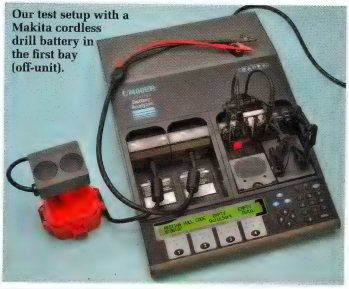
Since the locations of the lands will vary depending on battery type, there are multiple degrees of freedom which allows the probes on the arms to be moved so that they will contact the correct lands. The RigidArm has less degrees of freedom but because of this, it's easier and quicker to switch between batteries of the same type; the FlexArm probes must be positioned individually each time. However, both types are quite simple to set up and use.

Larger battery packs can be placed atop the units and the FlexArm can be arranged to have the arms pointed backwards to reach their terminals.

Battery service profiles

Each adaptor can be programmed with up to ten profiles (called "C-Codes"), which determine the battery chemistry, voltage, capacity, charge and discharge rates, termination voltages, test modes and so on. One of these profiles is set as the default and if a battery is connected to that adaptor, the unit will immediately prompt the user as to whether they want to start running that program.

So once it's set up, the unit is pretty easy to use; it's just a matter of plugging a battery in and pressing 'go'. You can set it up to bypass this step and just start operation if desired. It can also be set up to ask for an ID when a battery is inserted and it will then select an appropriate profile. When used in conjunction with a PC, it will also log the battery ID along with the servicing details for later analysis. This could be very useful for large organisations.



Our test setup with a Makita cordless drill battery in the first bay (off-unit).

Alternatively, technicians can take a more interactive approach and alter parameters for each battery that is connected, if required. This would be more typical in a service or repair situation.

While running the service program, the "Run" LED associated with that bay lights up and the LCD displays some information regarding what it is currently doing, the battery voltage and charge/discharge current. Once finished, it beeps and lights up either "Ready" or "Fail" depending on whether the battery is OK or not. Further information such as more specific details on the battery state can then be displayed.

So if you want to simply find out whether a battery is any good, and check that it's ready to go, this can be done at a glance.

Modes & features

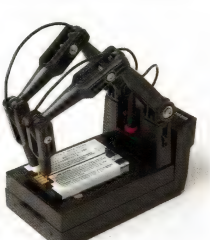
The unit can service batteries in a number of different modes. "Charge" mode just does a basic fast charge. "Auto" mode charges the battery and then does a quick discharge test. If this reveals that the battery is not performing as it should, it is then "reconditioned" with one or more discharge/charge cycles. If that fails to improve the capacity, the unit flags the battery as having failed.

"Prime" mode conditions a battery with repeated discharge/charge cycles. It stops when the battery capacity no longer improves. The "QuickSort"/"QuickTest" modes estimates the condition of a battery in a very short time (around 30 seconds) based on a stored profile of a known good battery. This is stored in the adaptor itself so can be customised to the type of battery inserted.

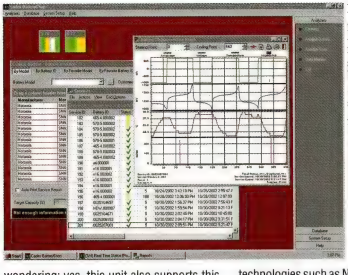
There are also several advanced modes that include self-discharge measurement, destructive testing to determine the number of charge/discharge cycles a battery will withstand, internal resistance measurement, battery runtime under various load conditions, residual capacity measurement (discharge testing), an extended "Prime" mode, and low-battery recovery ("Boost" mode). Custom modes can also be programmed.

The C7400ER-C can be connected to a Dymo label printer, and after testing can print a label indicating the state of a battery, which can then be affixed to it. This is a quick way for users to keep track of which batteries are good. If connected to a PC, a comprehensive report can be printed on a regular printer.

Oh, in case you have already seen the article on the Nicad/NiMH "Burp" Charger in this issue (starting on page 66) and are



Between the FlexArm (left) and the RigidArm (right) most battery types can be accommodated. There is also a range of specific battery connectors available.



For more in-depth analysis and/or to keep a permanent record of battery states, the unit can be connected to a PC and various software run to *really* tell you how your batteries are performing.

wondering: yes, this unit also supports this type of charging. They call it "Reverse Load" charging and it is enabled for Nicad & NiMH batteries it by default. The ratio of charge/discharge can be set in the battery profile.

Our experience

We started out using the C7400ER-C in stand-alone mode, ie, without hooking it up to a computer. In general, the unit is easy to drive. It automatically recognises when a battery is connected and prompts you to select its chemistry, voltage, capacity, what mode to use and so on. Once you have input this information, you press enter and it begins to charge/discharge/test the battery immediately.

By default, the display shows the status of each of the four bays. You can then press the large button under each bay, labelled with its number, to get more detailed information about what's going on with that battery. As well as showing the current action, terminal voltage and charge/discharge current this also shows the battery pack impedance (if measured) and its temperature.

When set to automatic mode and a battery is connected, the unit does what it thinks is required to bring it up to full charge and capacity. Master Instruments provided us with a 12V Nicad replacement pack for Makita power tools (which they make in-house) and when we popped it on the Analyser, it did a quick charge and discharge test and confirmed it was in good condition and no further action was required.

We also tried connecting some Li-po cells that had been lying around (for quite a while...), also in Auto mode, and it behaved somewhat differently, subjecting them to more thorough testing and in the case of the obviously more poorly cells, attempted to re-condition them with a full discharge and recharge. This sort of re-conditioning is most likely to succeed for older battery technologies such as Nicad and NiMH, which are still in fairly common use, however it may be beneficial for Litihium-based cells too.

One thing it took us a while to figure out (even with the user manual handy) was how to abort battery servicing. It turns out to be pretty simple – press the Alt key and then the associated battery bay button. This then gives you the option to restart the currently running program, which then allows you to change the profile settings or abort entirely.

It's a good idea to use this method to disconnect a battery during a test since simply yanking the battery out risks arcing which could damage the contacts of either the battery or the unit itself. However if the battery is disconnected while being serviced, the unit will sense this and stop whatever it is doing. If the battery is quickly re-connected, the previously running program will automatically resume, otherwise it aborts the program.

Performance

As stated earlier, the unit can handle batteries up to 36V and charge or discharge at up to 6A, however there is a limit of 75W per bay/battery, ie, with higher terminal voltages, the maximum current is reduced. Also, there is a total limit of 170W for charging and 200W for discharging across the four bays. If this would be exceeded, the unit will either reduce the charge/discharge current or pause action on one or more batteries until others finish. In practice though, you wouldn't commonly need full power on all bays simultaneously.

Accuracy is specified as ±1% for voltages and ±2% for currents which is good enough for most purposes. There is a procedure to re-calibrate the unit if necessary and you can also re-calibrate the individual adaptors, as the unit measures and stores their internal resistance to allow for more accurate battery voltage and impedance measurements.

Advanced features

If your organisation uses a lot of similar batteries, the unit can 'learn' how a good example behaves. Other batteries of the same type can then be tested against this model for a very quick assessment of their state ("Excellent", "Good", "Marginal" or "Poor").

Custom tests and procedures can be programmed, eg, if a battery needs to be 'exercised' periodically in a specific way, the unit can be programmed to do this without the need for user interaction.

The optional "BatteryShop" software can be used not only to manage and track multiple Battery Analysers can also produce graphs of the performance of a specific battery over time, including how capacity and impedance vary each time a battery is connected to the unit (including date stamps). Reports can be printed of the state of a given battery each time it is serviced or charged.

For really advanced battery analysis, the BatteryShop software can also produce a graph showing how the battery voltage, internal resistance and temperature vary over time during charge and discharge, in comparison to the current flow (see screenshot). The unit(s) connect to the PC via USB.

Overall, we would have to say that this Analyser has a very comprehensive set of features and is quite easy to use. It can handle most rechargable batteries in use today.

Using one of these units to manage a large set of batteries would be far better than having a hodge-podge of different chargers, especially given that some battery chargers don't always do the best job and can in fact lead to a shortened battery service life (eg, due to overcharging).

Where from?

The Cadex C7400ER-C Battery Analyser is available from Master Instruments. Their range of Cadex products can be viewed at **www.master-instruments.com.au/category/Cadex_Battery_Analyser_Charger_Conditioner/1232**

You can also call them at one of the following numbers: NSW/ACT – (02) 9519 1200, Vic/Tas – (03) 9872 6422, Qld – (07) 5546 1676 or WA/SA/NT – (08) 9302 5444. Or e-mail **info@master-instruments.com.au** for more information.

In addition to the more common types of battery adaptors, they also stock the C7400-C, which is a similar instrument to the C7400ER-C but has a more limited range of voltage and current (up to 16V, 4A). Or if your needs are more modest, you could consider C7200-C which is a two-bay version of the C7400-C. SC

Burp Charge Your Batteries

for better cell health

By JOHN CLARKE

Most readers know that Nicad and NiMH batteries can be fast charged but an even better way of doing it is to "burp" charge them. This is a rapid alternate charge and discharge process that reduces pressure and temperature build-up in the cells and as a result, increases the charging efficiency.

THIS VERY versatile Nicad & NiMH Burp Charger can charge a single cell or up to 15 series-connected cells. All the standard charge cycles such as fast charge, top-up and trickle are available, together with the added benefits of burp charging. Built-in safeguards include temperature sensing of the cells to prevent overcharging, as well as sensing inside the charger itself for over-temperature protection.

The concept of burp charging has been known since the late 1960s. At that time though, the many benefits thought to be associated with it were largely unsubstantiated. A specialised IC (the ICS1702) was developed that incorporated burp charging (see http://www.klaus-leidinger.de/mp/RC-Elektronik/Reflexlader/ics1702.pdf) and this became the basis for commercial burp chargers and for chargers used by NASA for nicad cells in space applications. However, these chargers were used without any real understanding as to why burp charging was beneficial.

It wasn't until 1998 that an exhaustive investigation compared standard charging with burp charging in a research paper entitled "Investigation of the Response of NiMH Cells to Burp Charging" by Eric C. Darcy (see http://corsair.flugmodellbau.de/files/elektron/NASA-ILPDF or in condensed form at ntrs.nasa.gov/search.jsp?R=20000086665). This research proved that burp charging improved cell performance compared to other charging techniques.

Basically, it was found that the burp process caused the oxygen bubbles

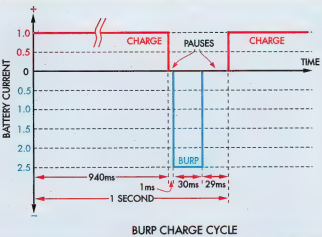


Fig.1: the charge, pause & discharge (burp) cycles for the SILICON CHIP Nicad/NiMH Burp Charger. It comprises a 940ms charge period followed by a 1ms pause, then a 30ms discharge period, followed by a 29ms pause, giving a total cycle of one second.

produced during charging to be re-absorbed back in the electrochemical process. With oxygen levels lowered, there is less pressure build up inside the cell. In addition, the lack of oxygen bubbles increases the available surface area on the cell electrodes and results in more efficient charging.

The research also found that while many commercial burp chargers, including those that use the ICS1702 IC, used a 5ms discharge (burp) period, a period of 30ms was more beneficial. That's because a longer discharge period allows more complete recombination of generated oxygen. For that reason, a 30ms burp period is used in the new design described here.

By the way, the term "burp" charging is something of a misnomer as the oxygen is not "burped" or released. Instead, it is recombined or consumed at the positive electrode surface.

Charge/discharge cycle

Fig.1 shows the sequence of charge, pause and discharge (burp) for the SILICON CHIP Nicad/NiMH Burp Charger. It comprises a 940ms charge period followed by a 1ms pause, then a 30ms discharge period, followed by a 29ms pause, giving a total cycle of one second (1s). On this figure, a charging period is shown as having a value of '1' while a discharge (burp) period is assigned a value of -2.5. This simply means that the discharge current is 2.5 times the charge current.

This cycle differs markedly from that used in the Burp Charger published in the August 1995 issue of "Electronics Australia". In that circuit, the charge and burp discharge periods were the same at 10ms each. This was due to the very simple circuit design which used the positive half of the AC waveform from a low-voltage transformer for charging and the negative half of the AC waveform for discharging.

The circuit was designed so that the discharge current was much less than the charge current, otherwise charging wouldn't have occurred. However, this charge/discharge cycle was far from ideal.

Burp chargers are not commonly available but standard NiMH/Nicad chargers can be obtained just about anywhere. However, the latter usually only charge two or four AA cells at a time and they charge at quite a slow rate, typically taking 4-15 hours for a full recharge.

But what if you want to charge at a much higher rate, or you want to charge more than four cells at a time, or if you want to use burp charging? Or what if you want to cater for 'C' and 'D' cells or battery packs? The answer is to build the SILICON CHIP Nicad/NiMH Burp Charger.

This new unit can charge from 1-15 NiMH or Nicad cells simultaneously; ie, battery packs up to 18V. In addition, the charging rate can be set from just a few milliamps up to 2.5A and it includes reliable end-of-charge detection (using temperature sensing), with extra safeguards to prevent over-charging.

Safety is important when charging NiMH and Nicad cells because they can have their life seriously shortened if the charger is left on for too long after the battery pack has reached full charge. Worse still, the cells can be destroyed or explode if over-charged.

To see why over-charging can destroy a battery pack, take a look at Fig.2. This shows the typical voltage, temperature and internal pressure rise of a cell or battery pack during charging. Once charging goes past the 100% point, the temperature and internal pressures rapidly rise, while the voltage initially rises and then falls.

Continual overcharging will damage the cells due to the elevated temperature. This accelerates chemical reactions that contribute to the cell's ageing process. In extreme cases during overcharging, excessive internal pressure can open the safety vents to release the pressure. These vents

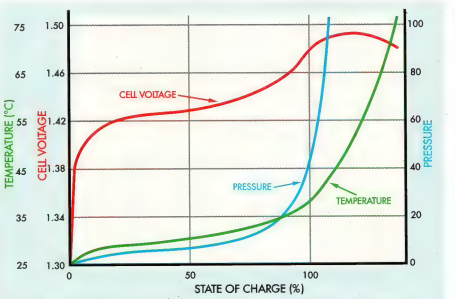


Fig. 2: typical charging curves for NiMH/Nicad batteries. Cell temperature (green) and voltage (red) rate of change are often used to detect the "end point" (100% charge), although voltage rate detection is not reliable in NiMH cells.

Main Features

- Designed for charging NiMH and Nicad cells
- Optional top-up and trickle charging
- Optional burp charging
- Adjustable charge current
- Charging time-out
- dT/dt (temperature change rate) for end of charge detection
- Over and under cell-temperature detection
- Power, charging and temperature indication LEDs
- Adjustable charging time-out limit
- Adjustable dT/dt setting
- Adjustable top-up and trickle charge currents
- Over-temperature cut out for charger

will then re-close after the pressure has been released but by that time the cells will already have been damaged.

Full charge detection

Full charge can be determined in one of two ways. The conventional way has been to monitor the voltage across the battery pack and detect the point at which the voltage suddenly begins to rapidly rise and then fall. This form of charge end-point detection is called dV/dt (ie, change in voltage with respect to time).

In practice, the critical end-point can be difficult to detect at low currents, particularly with NiMH cells. In fact, dV/dt end-point detection with NiMH cells is neither safe nor practical. The only safe way is to monitor the temperature of the cells but very few chargers do this.

Basically, this latter method of end-point detection monitors the temperature rise of one or two cells within the battery pack. During charging, the cells do not heat up much because most of the incoming power is converted into stored energy. However, once the cells become fully charged, the charging power is converted to heat and so the cells quickly rise in temperature.

This temperature change at the charging end point is called dT/dt, ie, change in temperature over time. The critical rate is of the order of 2°C per minute and this is the point where normal charging should cease.

Some chargers, this one included, include a top-up charge after the end-point to ensure full charging. The top-up charge rate is less than the main charge current and is set at four times the trickle current setting.

Finally, after the top-up cycle, the cells can be trickle-charged at low current to maintain full charge. In this situation, the cells are deliberately left connected to the charger so they are fully charged when needed.

Our new burp charger monitors the cell temperature using a small thermistor. This is installed in the battery pack or cell holder, in close contact with one of the cells. The beauty of this system is that it will reliably detect the end of charge (end-point) of any type of cell, regardless of whether it was initally completely flat or only partially discharged.

Note that when charging very cold batteries, there may be a rapid rise in temperature during charging. This could cause a false dT/dt end of charge indication. To circumvent this, the dT/dt measurement for end of charge detection is only enabled when the cell temperature is at least 25°C. Should the thermistor end-point detection fail, a timer is included that will switch off charging after a preset period.

Further safeguards to protect the cells are also included. For example, charging will not start or will cease if the NTC thermistor is disconnected or if the temperature is under 0°C or over 50°C. In addition, if the charger itself becomes too hot, charging will pause and the temperature is measured after two minutes to check if it has cooled sufficiently to restart.

Select the features you want

In its simplest form, the charger includes only the temperature detection feature, after which charging ceases. However, you can add top-up and trickle charging if you want. In addition, the charging rate can be set for both the main charge current and the trickle charge, along with the time-out period and dT/dt values.

In practice, the main charging rate can be set from about 40mA up to 2.5A, while trickle-charging can be set from 10-500mA. The time-out can be set from between 0-25 hours, while dT/dt can be selected from between 0.5°C per minute to 5°C per minute.

Further details concerning these adjustments are included in the setting-up section of this article.

Three front-panel LEDs are used to indicate the status of the charger. First, the Power LED is lit whenever power is applied to the charger, while the Thermistor LED lights if the thermistor is disconnected or if there is an over or under-temperature detection. For over-temperature (>50°C), the Thermistor LED will flash once a second (1Hz) while for under temperature (<0°C), the LED will flash once every two seconds (0.5Hz).

Over-heating of the charger itself causes the Thermistor LED to flash once every four seconds.

Finally, the Charging LED is continuously lit during the main charging cycle and switches off when charging is complete. If top-up or trickle charging are selected, the charging LED will flash at 1Hz during top-up and at 0.5Hz during trickle charge (ie, at 1s and 2s intervals respectively).

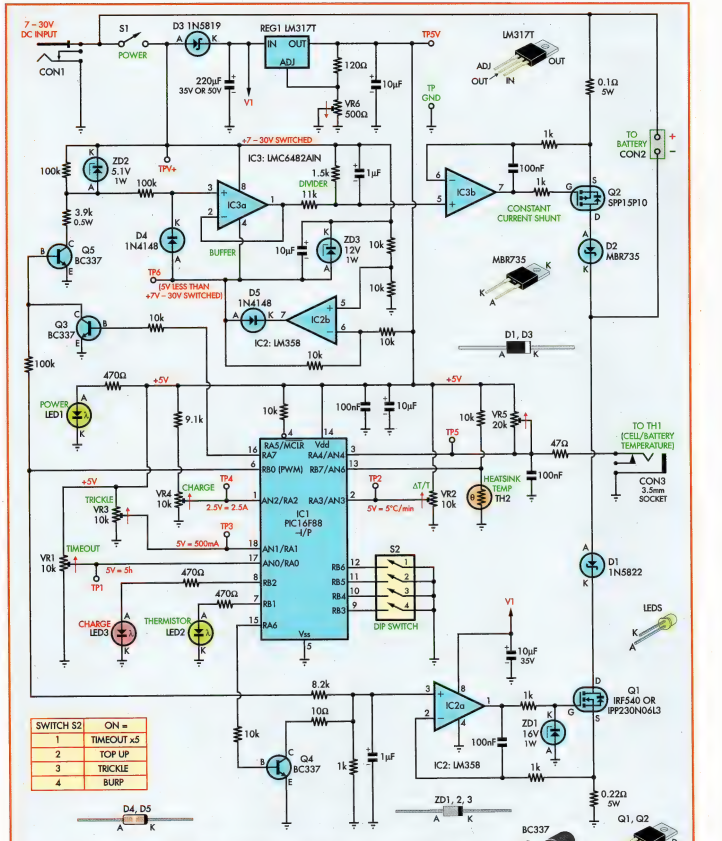
Note that if the Thermistor LED is lit or flashing, the charging LED will be off, indicating that charging has either paused or ceased.

Circuit details

Now take a look at Fig.3 for the circuit details. It's based on IC1, a PIC16F88-I/P microcontroller, plus Mosfets Q1 & Q2. Q1 is used for charging, while Q2 is used for the burp discharging.

In addition, two NTC thermistors, TH1 & TH2, are used. TH1 monitors the temperature of the cell or battery pack being charged. It's connected via a 3.5mm jack plug and socket (CON3) and together with 20kΩ trimpot VR5, forms a voltage divider across the 5V supply. VR5 is adjusted so that the voltage across the thermistor is 2.5V at 25°C (note: NTC stands for "negative temperature coefficient" and means that the resistance of the thermistor is progressively reduced as the temperature rises).

The voltage across TH1 is monitored at the AN4 input (pin 3) of IC1 via a 47Ω resistor and 100nF filter capacitor. These are included to remove RF (radio frequency) signals and noise that could be present due to the thermistor being connected remotely from the circuit. The voltage at the AN4 input is then converted into a digital value and monitored for dT/dt changes. It is also compared by IC1 against stored over and under-temperature values.



SWITCH S2	ON =
1	TIMEOUT x5
2	TOP UP
3	TRICKLE
4	BURP

BURP CHARGER FOR NICAD/NIMH BATTERIES

Fig.3: the circuit is based on IC1. This accepts inputs from TH1 & TH2, trimpots VR1-VR5 and DIP switch S2, sets the charge rates and the time-out, and controls the charging current through Q1 via its PWM output (RB0). IC1's PWM output also drives Q5 & IC3a which then drive a current shunt based on IC3b & Q2 to provide the discharge circuit.

Parts List

1 PCB, code 14103141, 105 x 87mm
1 119 x 94 x 34mm diecast case (Jaycar HB-5067 or equivalent)
1 2.5mm DC socket (Jaycar P-0621A, Jaycar PS-0520 or equivalent) (CON1)
1 3.5mm stereo PCB mount jack socket (Altronics P0092, Jaycar PS-0133 or equivalent) (CON3)
1 3.5mm mono line jack plug
1 SPDT toggle switch, PCB mount (Altronics S1421 or equivalent) (S1)
1 2-way screw terminal, 5.08mm spacing (Altronics P2040, Jaycar HM-3130) (CON2)
1 4-way DIP switch (Altronics S3050, Jaycar SM-1020 or equivalent) (S2)
2 DIL 8-pin sockets (optional)
1 DIL18 IC socket
2 10kΩ @ 25°C NTC thermistors (Jaycar RN-3440 or equivalent) (TH1,TH2)
1 crimp eyelet, 5.3mm ID (to mount TH2)
3 TO-220 silicone insulating washers
3 TO-220 insulating bushes
1 cable gland for 3-6.5mm cable
4 rubber feet
4 M3 x 6.3mm tapped spacers
8 M3 x 5mm screws
5 M3 x 10mm screws
5 M3 nuts
1 M3 star washer
1 200mm length of single-core screened cable
7 PC stakes
Hook-up wire, heatshrink, etc

Semiconductors

1 PIC16F88-I/P microcontroller programmed with 1410314A.hex (IC1)
1 LM358 dual op amp (IC2)
1 LMC6482AIN CMOS dual op amp (IC3)
1 LM317T adjustable regulator (REG1)
1 IRF540 or IPP230N06L3 N-channel Mosfet (Q1)
1 SPP15P10PLH P-channel logic level Mosfet (Q2)
3 BC337 NPN transistors (Q3-Q5)
1 1N5822 3A Schottky diode (D1)
1 MBR735 7A Schottky diode (D2)
1 1N5819 1A Schottky diode (D3)
2 1N4148 diodes (D4,D5)
1 16V zener diode 1W (ZD1)
1 5.1V zener diode 1W (ZD2)
1 12V zener diode 1W (ZD3)
2 3mm green LEDs (LED1, LED2)
1 3mm red LED (LED3)

Capacitors

1 220µF 35V or 50V PC electrolytic
4 10µF 35V or 50V PC electrolytic
2 1µF 16V PC electrolytic
4 100nF 63V or 100V MKT polyester

Trimpots

4 10kΩ horizontal trimpots (VR1-VR4)
1 20kΩ horizontal trimpots (VR5)
1 500Ω horizontal trimpot (VR6)

Resistors (0.25W, 1%)

3 100kΩ	5 1kΩ
1 11kΩ	3 470Ω
8 10kΩ	1 120Ω
1 9.1kΩ	1 47Ω
1 8.2kΩ	1 10Ω
1 3.9kΩ 0.5W	1 0.22Ω 5W
1 1.5kΩ	1 0.1Ω 5W

TH2 is connected to the AN6 input of IC1 and monitors the charger's heatsink temperature. This allows IC1 to shut the charger down if the heatsink temperature exceeds a preset value.

Trimpots VR1, VR2 & VR3 are used to set the time-out, dT/dt and trickle charge values. These trimpots connect to AN0, AN3 & AN1 of IC1 respectively and are be set to apply between 0V and 5V to these inputs.

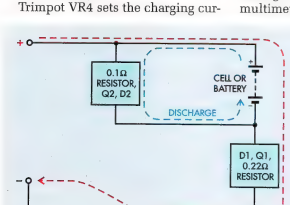
Trimpot VR4 sets the charging current. This trimpot connects to the +5V supply via a 9.1kΩ resistor and this restricts the adjustment range to a nominal 2.5V maximum at IC1's AN2 input (pin 1), corresponding to a 2.5A maximum charge rate.

The voltage inputs are all converted to digital values within IC1 so that the settings can be processed in software. Test points TP1-TP5 are provided for setting the trimpots when using a multimeter. There is also a TP GND terminal which is useful when checking these voltages.

The voltages measured at each test point directly relate to the setting's value. For example, setting VR1 to give 4V at TP1 will set the time-out to four hours. This time-out value can be multiplied by a factor of five by setting the No.1 switch in DIP switch S2 to the ON position. This ties pin 12 (RB6) of IC1 to ground.

Conversely, with this switch open, pin 12 is pulled to +5V via an internal pull-up resistor within IC1 and the time-out is set to x1. Switches 2, 3 & 4 in DIP switch S2 work in a similar manner. The No.2 switch enables the top-up, the No.3 switch enables the trickle charge mode and the No.4 switch enables the burp charge.

Outputs RB1 and RB2 of IC1 drive the Thermistor and Charge indicator LEDs (LED2 & LED3) respectively via 470Ω resistors. These indicate the charger's status, as described previously.



CHARGE & DISCHARGE CURRENT FLOW

Fig.4: the basic charge and discharge current paths for the unit. During charging, current flows from the power supply, through the cell or battery and then via diode D1, Mosfet Q1, and a 0.22Ω resistor to ground. Conversely, during discharge, current flows from the cell or battery through Mosfet Q2, diode D2 and a 0.1Ω resistor.

Charge & discharge

Two separate circuits are used for

the charge and discharge functions. To understand how this works, refer to Fig.4 which shows the basic charge and discharge current paths.

During charging, current flows from the power supply through the cell or battery and then via diode D1, Mosfet Q1 and a 0.22Ω resistor to ground. Conversely, during discharge, current flows from the cell or battery through diode D2, Mosfet Q2 and a 0.1Ω resistor. Note, however, that this is a simplified diagram and the currents through Q1 and Q2 are controlled so that charge and discharge rates are correct for the cell or battery that's connected to the charger.

Refer back now to Fig.3 for the full details. A constant current source comprising op amp IC2a and Mosfet Q1 charges the battery via CON2. IC1's RB0 output provides a 5V 3.9kHz PWM (pulse width modulated) signal which is fed to a divider and filter network comprising 8.2kΩ and 1kΩ resistors and a 1µF capacitor. This filter network smooths the pulse output to give a DC voltage.

This smoothed DC voltage sets the current provided by Q1 to the battery and the 5V PWM signal has its duty cycle adjusted over a wide range, from trickle to full charge. The 5V level is effectively reduced to 543mV via an 8.2kΩ and 1kΩ voltage divider. As a result, the maximum voltage that can be applied to pin 3 of IC2a is 543mV when the PWM duty cycle is 100% (ie, full charge). For a 50% duty cycle, the average voltage from RB0 is 2.5V, or 271.5mV after passing through the divider.

This filtered voltage is applied to pin 3 of IC2a and this sets the charge current. When pin 3 is at 543mV, IC2a's pin 1 output adjusts the gate drive to Mosfet Q1 so that the voltage across the 0.22Ω source resistor (as monitored at pin 2 of IC2a) is also 543mV. The charge current is therefore 2.47A (ie, 543mV ÷ 0.22Ω).

Diode D1 is included to prevent current flow via Q1's intrinsic reverse diode if power is connected with reverse polarity. D1 is a 3A Schottky type, specified because it has less than half the forward voltage of a normal power diode. Typically, it has about 380mV across it (at 2.5A) compared with a standard diode which would have 0.84V across it at 2.5A.

That also means less power loss in the diode; 0.95W for the Schottky diode compared to 2.1W in a standard diode.

IC1's RA6 output drives transistor Q4. This transistor is used to pull the voltage at pin 3 of IC2a to a very low level, so that the charge current is effectively reduced to near zero. This shut down is required during pause (when the PWM is also dropped to zero) and also during discharge when the PWM is still present to provide the discharge current setting.

Burp discharge

Another constant current circuit is employed for the burp discharge function. This comprises op amp IC3b and Mosfet Q2, with a 0.1Ω source resistor used for current monitoring. This circuit is connected to the positive supply (instead of the 0V supply as for the charge circuit) and so Q2 is a P-channel Mosfet. In addition, the PWM signal for IC1 is inverted and referenced to the positive supply.

The same PWM signal from RB0 (pin 6 of IC1) is also used to control IC3b & Q2. However, because we now have a P-channel Mosfet, the signal is inverted and level-shifted by transistor Q5. When the PWM signal is at 5V, Q5 switches on and its collector goes low, pulling one side of the 3.9kΩ resistor low. This 3.9kΩ resistor limits the current flow through 5.1V zener diode ZD2, This zener diode clamps the inverted voltage to within 5V of the switched supply rail.

As a result, the 5V PWM signal is now inverted and referenced below the positive supply which can be as high as 30V, depending on the number of cells being charged.

IC3a is powered from a 5V supply; ie, between the 30V positive rail at its pin 8 and a rail 5V below this at pin 4. A 100kΩ resistor couples Q5's output to pin 3 of IC3a and this resistor limits the current into clamp diode D4. D4 prevents the voltage applied to pin 3 going much below the pin 4 rail, thereby preventing damage to this op amp.

IC3a essentially buffers the PWM signal before feeding it to op amp IC3b via an 11kΩ/1.5kΩ divider. A 1µF capacitor filters the divider's output. This divider is designed to automatically provide a discharge current that's 2.5 times greater than the charge current.

Specifications

- Maximum input voltage: 30V.
- Maximum charge current: 2.5A.
- Charge current adjustment: from 0-2.5A, corresponding to 0-2.5V at TP4 using VR4 (in approximately 40mA steps).
- Time-out adjustment: from 0-5 hours, corresponding to 0-5V at TP1 using VR1. 0-25 hour with x5 selected (when DIP switch 1 closed).
- dT/dt adjustment: from 0.5-5°C rise/minute, corresponding to 0.5-5V at TP2 as set by VR2.
- dT/dt measurement interval: once every minute when cells reach 25°C or more.
- Top-up and trickle charge: top-up available when DIP switch 2 is closed; trickle enabled when DIP switch 3 is closed.
- Trickle charge: adjustable using VR3 from 0-500mA, corresponding to 0-5V at TP3. Adjustable in approximately 5mA steps.
- Top-up charge: 4 x trickle setting for one hour.
- Burp discharge: enabled when DIP switch 4 is closed. Discharge current is 2.5 times the charge current. Time-out is increased by 13% to compensate for reduced charge period and added discharge period.
- Cell over-temperature cut-out: 50°C.
- Cell under-temperature cut-out: 0°C.
- Charger over-temperature cut-out: 40°C.
- Charging cycle with burp selected: charge period 940ms, pause 1ms, burp discharge 30ms and pause 29ms (all over a 1s period).

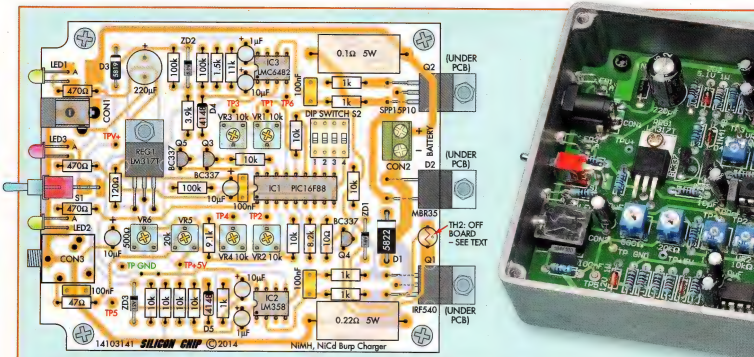


Fig.5: install the parts on the PCB as shown in this layout diagram and photograph. The text describes the mounting details for Q1, Q2 & D2 (see also Fig.6), thermistor TH2 and the three LEDs.

The 5V inverted PWM signal that's now referenced to the positive supply becomes a 600mV signal (again referenced to the positive supply) after the divider. When the PWM level is at maximum (ie, the charge current is 2.47A), 600mV appears across Mosfet Q2's 0.1Ω source resistor. This results in a 6A discharge current, ie, close to 2.5 times the charge current.

Power supply

Power for the circuit comes from a 7-30V DC supply (plugpack or laptop supply) via Schottky diode D3. D3 provides reverse polarity protection for the following 220µF capacitor and 3-terminal regulator REG1, an LM317T set to provide 5V to IC1 and the trimpots. This was chosen in preference to a fixed 5V regulator because it can be adjusted to supply a more precise 5V, using trimpot VR6. An exact 5V rail makes the settings of VR1-VR5 more accurate.

The 5V supply for op amps IC3a & IC3b is provided by IC2b. This is connected to invert the 5V from REG1 and level-shift it so that it is 5V below the positive supply rail. 12V zener diode ZD3 prevents IC2b's output from going more than 12V below the positive supply rail at power up. This protects IC3 from damage as its maximum supply rating is 16V.

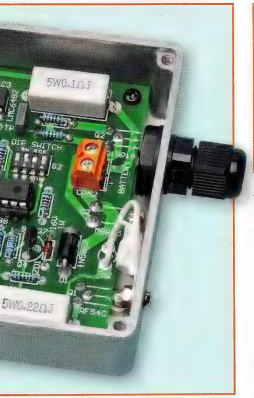
D5 prevents IC2b's output from conducting current through the 12V zener diode in the forward direction if the power supply is reversed in polarity. This also protects IC3 from damage.

Supply voltage requirements

In order to fully charge a battery, we need up to 1.8V per cell from the plugpack even though the nominal

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	3	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	11kΩ	brown brown orange brown	brown brown black red brown
❑	8	10kΩ	brown black orange brown	brown black black red brown
❑	1	9.1kΩ	white brown red brown	white brown black brown brown
❑	1	8.2kΩ	grey red red brown	grey red black brown brown
❑	1	3.9kΩ	orange white red brown	orange white black brown brown
❑	1	1.5kΩ	brown green red brown	brown green black brown brown
❑	5	1kΩ	brown black red brown	brown black black brown brown
❑	3	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	120Ω	brown red brown brown	brown red black black brown
❑	1	47Ω	yellow violet black brown	yellow violet black gold brown
❑	1	10Ω	brown black black brown	brown black black gold brown
❑	1	0.22Ω	red red silver brown	black red red silver brown
❑	1	0.1Ω	brown black silver brown	black brown black silver brown



terminal voltage shown on the battery pack is 1.2V per cell. So, to charge a 6V battery which has five cells, we need a DC input voltage of 5 x 1.8V = 9V.

Similarly, an 18V battery has 15 cells and so this requires a 15 x 1.8V = 27V supply to fully charge it.

Charging only one, two or three cells nominally requires up to 5.4V. In practice though, more than 7V is required at the input to ensure that the LM317T regulator (REG1) operates correctly, ie, remains in regulation.

For operation in a car, the input voltage will be around 12V with the engine stopped and up to 14.4V with the engine running. A 12V supply can charge up to six cells (ie, a 7.2V battery), while a 14.4V supply (with engine running) can charge up eight cells (ie, a 9.6V battery).

Note also that using a supply voltage that is significantly higher than required to charge the cells will cause the charger to heat up more than necessary. For example, at 2.5A and with a supply that's 10V higher than the battery voltage, around 25W will be dissipated in the charger. In that case, the charger will certainly become hot and will shut down when its heatsink (ie, the case) reaches 40°C.

Basically, this means that the charge current may have to be reduced if the supply voltage is high compared to the battery voltage. The maximum charging current is also limited by the mAh capacity of the cell or battery (see Table 2) and the rating of the DC plugpack or power supply. So in order to charge at 2.5A, the power supply or plugpack must be able to deliver this current.

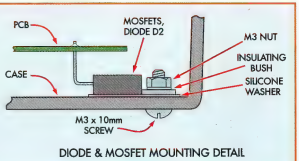


Fig.6: diode D2 and Mosfets Q1 & Q2 are mounted on the base of the case and are insulated from it using insulating bushes and silicone washers. Make sure that the metal tab ends of the devices cannot short against the side of the case.

Construction

The assembly is straightforward since all the parts are mounted on a PCB coded 14103141 and measuring 105 x 87mm. This is housed in a metal diecast case measuring 119 x 94 x 34mm.

Fig.5 shows the assembly details. Begin construction by checking the PCB for any defects such as shorted tracks, breaks in the copper and incorrect hole sizes. Also, check that the corners at the lefthand end of the PCB have been shaped to clear the internal corner posts. It's rare to find any problems but it's always a good idea to check before installing any of the parts.

Next, place the PCB inside the case and mark out the corner mounting holes in the base, noting that the PCB must sit as far to the left as it will go. This is necessary so that switch S1 and the 3.5mm socket later protrude through the case side. Drill these mounting holes out to 3mm and deburr them using an oversize drill.

Now for the PCB parts. Install the small resistors first, taking care to fit the correct value in each location. Table 1 shows the resistor colour codes but it's always a good idea to use a digital multimeter check each one before installing it (some colours can be difficult to read).

The 0.1Ω and 0.22Ω 5W resistors can go in next. These should be mounted about 1mm above the PCB to allow air to circulate beneath them for cooling. That's easily done by pushing them down onto a 1mm-thick cardboard spacer before soldering their leads (don't forget to remove the spacer afterwards).

Next, install the diodes (but not D2), then fit IC sockets for IC1, IC2 & IC3. Be sure to orientate each socket correctly, ie, with its notched end to the left. Once these are in, install the correct op amp in each position but leave the PIC16F88 micro out for the time being.

Follow with DIP switch S2, making sure that its No.1 switch goes to the left. The zener diodes can then be installed. ZD1 is a 16V 1W type and may be marked as a 1N4745; ZD2 is 5.1V 1W and may be marked as a 1N4733; and ZD3 is 12V 1W and may be marked as a 1N4742. Again, the orientation of these parts is important.

The capacitors can now be fitted, making sure that the electrolytics go in with the correct polarity. That done, install PC stakes for TP GND, TP +5V and test points TP1-TP5.

The three LEDs are next on the list, starting with LED1 (green). First, orientate it as shown on Fig.5, then bend its leads down at right angles 6mm from

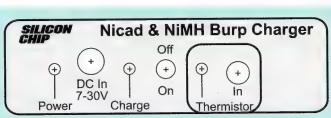


Fig.7: this full-size artwork can be used as a drilling template for the front side panel of the case.

Table 2: Typical Settings For A Range Of Cell Capacities

Battery Or Cell Capacity	Slow Charge (15h) (VR1 @ 3V, DIP Switch No.1 ON) (Do not select top up)	Standard Charge (5h) (VR1 @ 5V, DIP Switch No.1 off) (Top up not recommended)	Fast Charge (1.5h at or below 2.5A) (VR1 @ 1.5V, DIP Switch No.1 off)	Trickle Current (DIP Switch No.3 on) (Top up with DIP Switch No.2 ON will be 4 x trickle setting)
200mAh	20mA (VR4 @ 20mV)	60mA (VR4 @ 60mV)	200mA (VR4 @ 200mV)	10mA (VR3 @ 100mV)
400mAh	40mA (VR4 @ 40mV)	120mA (VR4 @ 120mV)	400mA (VR4 @ 400mV)	20mA (VR3 @ 200mV)
700mAh	70mA (VR4 @ 70mV)	210mA (VR4 @ 210mV)	700mA (VR4 @ 700mV)	35mA (VR3 @ 350mV)
900mAh	90mA (VR4 @ 90mV)	270mA (VR4 @ 270mV)	900mA (VR4 @ 900mV)	45mA (VR3 @ 450mV)
1000mAh	100mA (VR4 @ 100mV)	300mA (VR4 @ 300mV)	1.0A (VR4 @ 1.0V)	50mA (VR3 @ 500mV)
1500mAh	150mA (VR4 @ 150mV)	450mA (VR4 @ 450mV)	1.5A (VR4 @ 1.5V)	75mA (VR3 @ 750mV)
2000mAh	200mA (VR4 @ 200mV)	600mA (VR4 @ 600mV)	2.0A (VR4 @ 2.0V)	100mA (VR3 @ 1.0V)
2400mAh	240mA (VR4 @ 240mV)	720mA (VR4 @ 720mV)	2.4A (VR4 @ 2.4V)	120mA (VR3 @ 1.2V)
2500mAh	250mA (VR4 @ 250mV)	750mA (VR4 @ 750mV)	2.5A (VR4 @ 2.5V)	125mA (VR3 @ 1.25V)
2700mAh	270mA (VR4 @ 270mV)	810mA (VR4 @ 810mV)	2.5A (1.6h) (VR4 @ 2.5V, VR1 @ 1.6V)	135mA (VR3 @ 1.35V)
3000mAh	300mA (VR4 @ 300mV)	900mA (VR4 @ 900mV)	2.5A (1.8h) (VR4 @ 2.5V, VR1 @ 1.8V)	150mA (VR3 @ 1.50V)
3300mAh	330mA (VR4 @ 330mV)	990mA (VR4 @ 990mV)	2.5A (2h) (VR4 @ 2.5V, VR1 @ 2.0V)	165mA (VR3 @ 1.65V)
4000mAh	400mA (VR4 @ 400mV)	1.2A (VR4 @ 1.2V)	2.5A (2.4h) (VR4 @ 2.5V, VR1 @ 2.4V)	200mA (VR3 @ 2.0mV)
4500mAh	450mA (VR4 @ 450mV)	1.35A (VR4 @ 1.35V)	2.5A (2.7h) (VR4 @ 2.5V, VR1 @ 2.7V)	225mA (VR3 @ 2.25V)
5000mAh	500mA (VR4 @ 500mV)	1.5A (VR4 @ 1.5V)	2.5A (3h) (VR4 @ 2.5V, VR1 @ 3.0V)	250mA (VR3 @ 2.5V)
9000mAh	900mA (VR4 @ 900mV)	2.5A (5.4h) (VR4 @ 2.5V, VR1 @ 1.08V, DIP Switch No.1 ON)	2.5A (5.4h) (VR4 @ 2.5V, VR1 @ 1.08V, DIP Switch No.1 ON)	450mA (VR3 @ 4.5V)

its body. That done, solder the LED in place with its horizontal lead sections exactly 5mm above the PCB (hint: use a 5mm-thick spacer to set the height). The remaining two LEDs can then be fitted in exactly the same manner.

Trimpots VR1-VR6 are next on the list. Note that the 10kΩ trimpots may be marked 103, the 20kΩ trimpots marked 203 and the 500Ω trimpot marked 501 (ie, instead of the actual ohm values).

Regulator REG1 is next and is mounted with its leads bent down at right angles so that its metal tab sits flat against the PCB. Secure this tab to the PCB using an M3 x 10mm screw, nut and shakeproof washer before soldering the leads.

That done, install the DC socket (CON1), the 2-way screw terminal block (CON2), the 3.5mm jack socket (CON3) and switch S1. Be sure to push these parts all the way down so that they sit flush against the PCB before soldering their leads.

That completes the PCB assembly, except for Q1, Q2 and D2. As shown on Fig.5, these three devices are all mounted under the PCB, with their leads bent up at 90° so that they pass through their respective mounting holes. This allows their tabs to be later bolted to the bottom of the metal case for heatsinking.

In each case, it's simply a matter of first bending the two outside leads up by 90° exactly 7mm from the device body. The middle leads of Q1 & Q2 can then be bent up 5mm from the body, after which you can loosely fit all three devices to the PCB but don't solder their leads yet. **Take care not to get the two Mosfets mixed up – Q1 is an IRF540 while Q2 is an SPD15P10.**

Case preparation

It's necessary to drill some extra holes in the case, before installing the PCB. The mounting holes for the PCB assembly were drilled in a previous step (ie, before the parts were installed) and the next step now is to use the front-panel artwork (Fig.7) as a drilling template for the front-panel holes.

You can either copy the artwork shown in Fig.7 or you can download the artwork in PDF format from the SILICON CHIP website (free for subscribers) and print it out. In either case, it should be cut out and attached to the case using adhesive tape, after which the various holes can be drilled.

Be sure to position the label so that the centre of the On/Off switch is exactly 16.5mm down from the top edge of the base.

Use a small pilot drill to start the holes, then remove the template and carefully enlarge each one to size using a large drill and/or a tapered reamer. There are six holes in all – three for the

LEDs and one each for the DC socket, 3.5mm jack socket and switch S1.

Once all the holes have been drilled, print out a final front-panel label, laminate it and attach it to the case using double-sided tape or silicone adhesive. The various holes can then be cut out with a sharp hobby knife.

Final assembly

Begin the final assembly by securing four M3 x 6.3mm tapped Nylon spacers to the base of the case using M3 x 5mm screws. The PCB assembly (together with the loosely-fitted Q1, Q2 & D2 parts) can then be slipped into the case and secured to the spacers using another four M3 x 5mm screws.

The next step is to drill the mounting holes for Q1, Q2 & D2. **These devices must be positioned so that the ends of their tabs clear the side of the case by 1-2mm.** If a tab does touch the side of the case, you will have to remove the offending device and re-bend its leads so that it is clear.

Once everything is correct, remove the PCB assembly and drill the device mounting holes to 3mm, then deburr them using a larger drill. It's vital that the area around each of these holes inside the case is perfectly smooth and free of metal swarf, so that the insulating washers used when mounting the devices will not be punctured.

A hole also needs to be drilled and reamed in the adjacent side of the box (ie, at the Q1/Q2 end) to accept a cable gland (position this directly opposite CON2), while a 3mm hole must also be drilled to mount thermistor TH2. Be sure to position the hole for the cable gland down far enough so that the gland doesn't later interfere with the lid of the case.

Mounting TH2

Thermistor TH2 is attached to a 5.3mm crimp eyelet which is then fastened to the inside of the case using an M3 x 10mm machine screw, nut and lockwasher (ie, to detect heatsink temperature).

First, remove the plastic insulating piece from the eyelet, then prise open the crimp section using pliers. That done, shape the crimp lugs so that they lightly clamp the thermistor in place but without the leads making contact to the crimp eyelet.

Finally, glue the thermistor in place using epoxy resin and heatshrink it, then refit the PCB assembly in the case and attach the thermistor assembly to the case wall using an M3 x 10mm screw, nut and lockwasher. The thermistor's leads are then connected to its pads on the top of the PCB – see Fig.5 and photo.

Bolting down Q1, Q2 & D2

Mosfets Q1 & Q2 and diode D2 can now be fastened to the bottom of the case. As shown in Fig.6, these devices must each be insulated from the case using a silicone washer and insulating bush. An M3 x 10mm screw and nut is used to secure each device in place, after which its leads are soldered to their pads on the top of the PCB.

Determining The Charger Settings

Before adjusting the time-out, trickle charge and time-out settings, you need to know the Ah rating (or mAh rating) of the cells or the battery. This will normally be printed on the side.

You also need to know the nominal battery voltage (or the number of cells connected in series to calculate this) and the voltage/current ratings of the plugpack.

Note that when using slow charging rates (eg, charging over 15 hours), the top-up current would exceed the charge rate. In this case, do not enable top-up. Similarly, at faster charging rates (eg, charging over five hours), the top-up current may be similar to the charge rate and again top-up is not recommended.

Charge rate

This will depend on the mAh rating of the cells or battery and on the desired charge rate (slow, standard or fast) – see Table 2. The plugpack used must also be capable of supplying the required current.

Time-out

The time-out should be set to 1.5 times the Ah rating of the battery divided by the charge current. For example, a 2500mAh (2.5Ah) battery charged at 1A should be fully charged after 2.5 hours. In this case, the time-out should be set to 2.5 x 1.5 ÷ 1 = 3.75h. That's done by adjusting VR1 to give 3.75V at TP1 (see text).

Note that any changes made to the time-out value during charging will not take effect until the power is switched off and on again. This also includes any changes to the DIP switch settings. Any changes to other settings will take effect immediately and will affect the current charging cycle.

Trickle charge

The trickle charge requirement is calculated by dividing the Ah (amp hour) rating of the cells by 20. So, for example, if the cells are rated at 2400mAh, then the trickle charge current should be set to 120mA.

Adjusting the dT/dt value

The endpoint temperature rise detection adjustment (dT/dt) should initially be set to 2.5°C per minute (ie, by adjusting VR2 for 2.5V on TP2). In some cases, however, the charger may stop before the battery is fully charged or conversely, it may tend to overcharge the battery.

Under-charging is indicated if the charging period appears to be too short and the batteries do not deliver power for the expected period. In this case, turn VR2 further clockwise to increase the dT/dt value.

Conversely, if the battery pack becomes quite hot after full charge has been reached, turn VR2 anticlockwise to decrease the dT/dt value.

This view shows how thermistor TH2 is attached to a 5.3mm crimp eyelet and fastened to one end of the case.

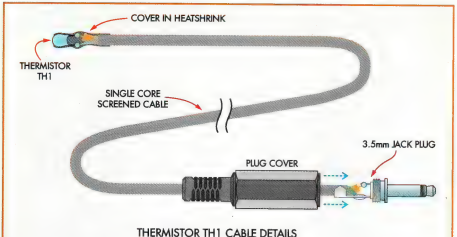


Fig.8: the battery-pack temperature sensor (TH1) is connected to the charger via a length of single-core screened cable and a 3.5mm jack plug. Be sure to heatshrink the thermistor connections so that they cannot short together.

Once all these devices are in, use a multimeter to check that the metal tabs of these devices are indeed isolated from the metal case. If you get a low resistance reading between a device tab and the case, dismantle the assembly and check that its insulating washer hasn't been punctured (eg, by metal swarf).

Check also that the device's tab is clear of the side of the case.

Battery-pack thermistor

As shown in Fig.8, the battery-pack thermistor (TH1) is connected to a 3.5mm jack plug via single-core screened cable. Be sure to sleeve the thermistor connections with heatshrink tubing to prevent any shorts between them or to the battery holder terminals.

The thermistor itself needs to be mounted in the battery holder so that it makes contact with the side of at least one of the cells under charge. For our prototype, we drilled a hole in a 2 x AA cell holder so that the thermistor is sandwiched between the cells when they are in place (see photo).

Alternatively, depending on the type of battery holder (or if no holder is used), the thermistor can be held in place against the cells using a length of hook and loop material.

The shielded lead running to the thermistor is secured to the end of the battery holder using a small cable tie and a couple of self-tapping screws.

Setting up

It's now time to make some initial voltage checks. First, with IC1 still out of its socket, connect a DC plugpack to CON1 (positive to the centre of the plug) and switch on. Check that the power LED (LED1) lights, then connect a multimeter between TP5V and TP GND and adjust VR6 for a reading of 5.0V.

Now check that there is 5V between pins 14 & 5 of IC1's socket. If so, check that TP6 is at -5V with respect to TPV+. If this is correct, switch off the power, wait a short time and then insert microcontroller IC1 (notched end to the left).

The battery pack thermistor (TH1) can be fitted to a 2 x AA cell holder by drilling a hole between the two compartments as shown here. Its leads are attached to a single-core shielded cable and this is secured using a cable tie which wraps around two self-tapping screws that go into the holder at one end.

Adjustments

Now for the final adjustments. This involves adjusting the various trimpots for charge rate, cell/battery temperature cut-out, time-out (ie, the maximum time for which the charger operates before it cuts out) and end-point temperature detection. The procedures are as follows:

- **Charge rate:** the charge rate is set using trimpot VR4 and will depend on the mAh rating of the cells or battery. It will also depend on the current rating of the plugpack power supply being used and on the desired charge rate (slow, standard or fast).

Table 2 shows the charge settings for cells/batteries ranging in capacity from 200mAh to 9000mAh. It's just a matter of choosing a charge rate to suit the cells or battery and adjusting VR4 to give the required voltage on TP4.

- **Cell/battery temperature cut-out:** this involves adjusting trimpot VR5 so that the voltage on TP5 is 2.5V when thermistor TH1 is at 25°C. So, if the ambient temperature is 25°C, simply adjust VR5 for 2.5V on TP5.

If the ambient temperature is 20°C, set VR5 for 2.8V on TP5. And if the ambient temperature is 30°C, set VR5 so that TP5 is at 2.2V.

Note that some battery packs will have a thermistor already installed. This should not be used unless it has the same resistance characteristics as the one specified for TH1. It should measure about 10kΩ at 25°C and the resistance should fall with increasing temperature.

- **Time-out:** the time-out is adjusted using VR1. This can be set from 0-25 hours by monitoring the voltage between TP1 & TP GND. The voltage on TP1 directly translates to the time-out in hours, so if it's set to 2.5V, the time-out will be 2.5 hours. And if it's set to its 5V maximum, then the time-out will be 5 hours.

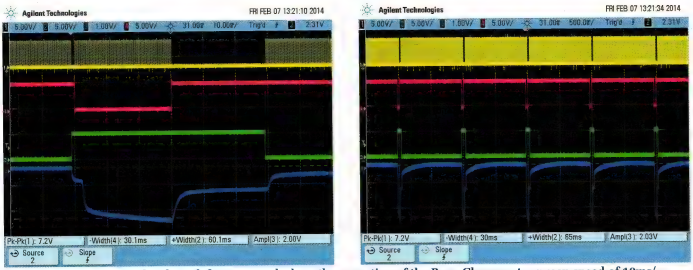


Fig.9: the waveforms in the above-left screen grab show the operation of the Burp Charger at a sweep speed of 10ms/div for a 100ms period. The yellow trace is the PWM signal from the microcontroller at pin 6; the pink trace is the 30ms discharge pulse from pin 16 to the base of Q3; and the green trace is the pulse signal from pin 15 to the base of Q4 which turns off Mosfet Q1 while the battery is being discharged and for 30ms after that. The blue trace shows the fluctuation in the battery voltage of a 4-cell Nicad pack. Note that it drops for 30ms (the burp period), then recovers and begins rising again as the charging cycle resumes. The screen grab to the right shows the operation at a much slower sweep speed of 500ms/div (5-second duration).

As stated, the No.1 switch in DIP switch S2 acts as a x5 multiplier for the time-out. So if this switch is set to ON and TP1 is set for +5V, the time-out will be 25 hours. Similarly, if TP1 is set to 1.2V, the time-out will be six hours (5 x 1.2).

The accompanying panel (Determining The Charger Settings) tells you how to calculate the time-out value required for the cells used. Table 3 also shows the typical settings for cells of various capacities.

- **Endpoint temperature rise detection:** VR2 is used to adjust the endpoint temperature rise detection (dT/dt). This can be adjusted from between 0.5°C per minute rise to 5°C per minute rise by monitoring the voltage between TP2 and TP GND. Once again, there is a direct correlation between the voltage and the setting.

For example, a setting of 2.5V at TP2 will set the dT/dt value to a 2.5°C per minute rise and this should be the initial setting. This can later be changed if you find that the battery pack is either being under-charged or over-charged (see panel).

Top-up/trickle charge options

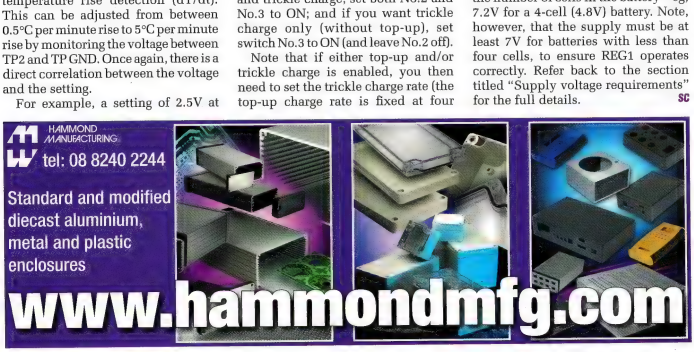
Setting the No.2 and No.3 switches in DIP switch S2 to ON enables the top-up and trickle charge modes respectively. These can be activated together or individually.

If you want top-up only, set switch No.2 to ON; if you want both top-up and trickle charge, set both No.2 and No.3 to ON; and if you want trickle charge only (without top-up), set switch No.3 to ON (and leave No.2 off).

Note that if either top-up and/or trickle charge is enabled, you then need to set the trickle charge rate (the top-up charge rate is fixed at four times the trickle charge rate). That's done using trimpot VR3, which allows adjustment from 500mA down to less than 20mA.

Once again, the panel tells you how to calculate the required trickle charge rate to suit your cells. It's then just a matter of monitoring the voltage at TP3 and adjusting VR3 accordingly (eg, 1V = 100mA, 3V = 300mA and 5V = 500mA).

Finally, as previously stated, you need to choose a power supply (eg, a plugpack) with an output voltage under load that's at least equal to 1.8 x the number of cells in the battery – eg, 7.2V for a 4-cell (4.8V) battery. Note, however, that the supply must be at least 7V for batteries with less than four cells, to ensure REG1 operates correctly. Refer back to the section titled "Supply voltage requirements" for the full details. SC



PRODUCT SHOWCASE

Verbatim MediaShare Wireless stores, streams and shares media content, anywhere

Verbatim introduces MediaShare Wireless – a portable device which connects with up to five Wi-Fi enabled tablets and smartphones allowing you to view, play, stream and back up photos, video clips and music simultaneously, anywhere.

With this unit you can connect up to five devices to the MediaShare simultaneously to share videos, music and data.

A built-in USB port and SD Memory slot allows easy access to content from a USB portable hard drive, USB Drive or SD memory card and expansion of available storage on smartphones and tablets.

You can also upload and download content wirelessly to and from your tablet or smartphone and safely back up photos and video clips from your smartphone or tablet to physical storage without needing a computer.

The MediaShare Wireless allows up to nine hours of continuous video playback. An easy-to-use MediaShare Wireless app, available to download from iTunes and Google Play for iOS and Android devices respectively, lets users manage content (copying files between devices and MediaShare Wireless).

It also provides a bridge to other wireless LAN networks to allow internet connections while files are being streamed.

This means you can continue to use the internet while streaming content from the MediaShare.

Contact:
Verbatim Australia
6/450 Princes Hwy, Noble Park, Vic 3174
Tel: (03) 9790 8999 **Fax:** (03) 9790 8911
Website: www.verbatim.com.au

'NZ' Series of Compact Switch Joysticks

A new line of switch joysticks from APEM bridges the gap between joysticks and switches. The 'NZ' series is designed for the control of either machine functions or menu navigation.

With above-panel options that mimic the look of either a joystick or toggle switch, they offer an IP67 panel-sealed, two-axis-control in a compact below-panel housing.

Constructed with gold-plated silver alloy contacts to provide reliable switching at low current levels, the NZ Series is rated for 2A or 100mA.

They feature an open square gate, allowing the user to move freely in 360°. This omnidirectional movement allows movement in a diagonal direction, which yields a contact on two switches simultaneously. As a standard option, the joystick may be factory fitted with an anodised aluminium limiter plate, limiting the travel to just NSEW or NS directions.

The series is rated for one million operations, with an operating temperature range of -25°C to +50°C.

Contact:
Control Devices
Unit 5, 79 Bourke Rd. Alexandria NSW 2015.
Tel: (02) 9330 1700 **Fax:** (02) 8338 9001
Website: www.controldevices.net

Design-specific enclosures for credit-card sized computers

Hammond Electronics has launched a range of design-specific moulded enclosures to support the new types of credit card sized, low cost bare board computers. The enclosures provide good protection for the board themselves, and have dedicated access positions for external connectivity such as Ethernet, USB and serial ports.

Although broadly similar in size and shape, there are inevitable differences in the positioning of I/O, power and expansion ports on each design.

Hammond's enclosures, derived from its popular 1593 family, are available in translucent blue, grey or black, and each version is configured for the particular design of board, with machined slots, cutouts and apertures in the cover and end panels. In some variants, the covers are moulded with the required access points. The new format of development boards are aimed at both professional developers and hobbyists.

Initially, the supported computers are the Arduino Uno, Due and Mega, the Beaglebone and Beaglebone Black and the Freescale Freedom. Enclosures for the Arduino Tre and Intel Galileo are in development and will be available soon. In such a fast-moving environment, new versions are regularly being added to support additional development board designs as they are introduced.

Contact:
Hammond Electronics Pty Ltd
11-13 Port Rd, Queenstown, SA 5014
Tel: (08) 8240 2244 **Fax:** (08) 8240 2255
Website: www.hammondmfg.com

Tibbits Pre-packaged I/O

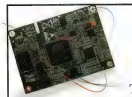
Tibbits (as in "Tibbo Bits") are blocks of prepackaged I/O functions housed in colour-coded plastic shells. Want an ADC? There is a Tibbit for this. 5V power supply? Got that! RS232/422/485 port? PoE? PWM? There are many other Tibbits, too, divided into Tibbit modules and Tibbit connectors.

Each BASIC-programmable Tibbo Project PCB (TPP) can accommodate multiple Tibbit modules and connectors. Only bare essentials are provided on each board – there is a CPU, an Ethernet port and a very simple power supply. The rest of the board's functionality is defined by what Tibbits you plug in. There are several TPP "sizes" that differ in the number of Tibbits they can accommodate.

TPPs are programmable in Tibbo BASIC. This easy-to-learn programming language is particularly suited for control, automation, and networking applications. Tibbo BASIC is complemented by a rich set of programming objects, including socket (TCP, UDP, HTTP) and serial communications, Wi-Fi, GPRS, file data storage, LCD and keypad control, and many other functions.

Tibbo BASIC applications are created using free Tibbo IDE software (TIDE). This features a built-in debugger, allowing you to upload your Tibbo BASIC application onto the TPP board and cross-debug it through the Ethernet LAN without the aid of any special debugging hardware (such as a JTAG board or an ICE machine).

Contact:
Tibbo Technology Inc 9F-3, No 31, Lane 169, Kang-Ning St, Hsi-Chih, Taipei, Taiwan
Tel: (886) 2 2692 5443 **Fax:** (886) 2 2692 3139
Website: www.tibbo.com



ARM-based SBC with touch-screen display for HMI applications

The EDM6070AR-01 fully-integrated Embedded Display Module (EDM) from element14 is ideally suited for a variety of embedded control HMI (human machine interface) applications including industrial control terminals, intelligent instruments, medical products, network terminals as well as data acquisition and analysis.

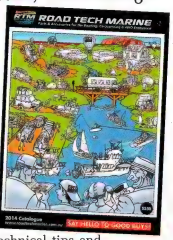
It integrates an ARM-based single board computer (SBC) with a 7-inch LCD and touch-screen assembly. The multi-function embedded EDM is based on the ARM9 AT91SAM9X35 industrial processor from Atmel. The module has a plate with display, connectors and place for the Mini6935 module with ARM microcontroller.

Included is 128MB SDRAM, 256MB NAND flash and 4MB data flash.

It is supplied with a Smart-Home demo application with an intuitive smart-LED controller allowing the user to set independent light levels in each room, smart-climate controller allowing the user to control temperature and humidity throughout the house and smart-multimedia allowing the user to play streamed audio files into any room and manage surveillance cameras.

Contact:
element14 Pty Ltd
72 Ferndell St, Chester Hill NSW 2162
Tel: (02) 9644 7722 **Fax:** (02) 9645 1381
Website: www.au.element14.com

New Catalog for Off-Road, Caravanning & Marine Enthusiasts



With a heavy emphasis on electronics and hardware, Road Tech Marine, Australia's new supplier for the boating, caravanning and off-road enthusiast has released an impressive first catalog for this market.

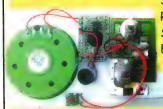
Featuring a detailed "Where's Wally?" type front cover showing a stylised outback 4WD/camping/boating scene, the full colour catalogue is 260 crammed pages, with over 4,200 products, technical tips and suggestions. It even has a recipe to make bread from beer!

The catalog is available to be posted to you via their website (see below) or by calling into any RTM store for just $3.95 – or it's FREE with any purchase over $100.

RTM Stores are located at Lawnton and Underwood (Qld), Granville and Caringbah (NSW), Fyshwick (ACT) and Dandenong (Vic). They have big expansion plans so be sure to check out their website for their newest stores and their increasing product line.

Contact:
Road Tech Marine
Reply Paid PO Box 7172, Silverwater NSW 1811
Tel: 1300 964 264 **Fax:** (02) 8832 3333
Website: www.roadtechmarine.com.au

KSSM-30Sec DIY SOUND RECORDER



30second recording time.
Robust sound output.
Simplified recording control.
Easy to Use
New Low Price
$7.77 inc. GST
Plus $3.60 P & P

KSDVM-30 ULTRA-COMPACT
4.5V-30VDC Digital Panel Meter

Here's a meter that is range-optimized for solar, automotive and trucking applications: Features:Bright 0.36" Red LED Digits, Snap-Fit Housing, 2 Wire Installation. Value $6.70 inc. GST Plus $3.00 Pack & Post

Hours of Fun - Our 5 Kit Bonanza

Kick 2014 off with this great set: A FK109 2 LED Flasher, FK908 Soil Moisture Indicator FK233 Emergency Vehicle Siren with speaker, FK602 2W Mono Audio Amplifier (Uses the FK233 Siren speaker) plus the FK401 Light-Activated Switch.

All for $25.50 Inc. GST Plus $8.50 Pack & Post

KitStop electronics – The fun starts here
On Line at www.kitstop.com.au
P.O. Box 5422 Clayton Vic.3168
Tel:0432 502 755

ALTRONICS

Build It Yourself Electronics Centre

Issue: March 2014

Upgrade & Save!

New movement activated models!

Super Bright Outdoor LED Security Lights.
Add peace of mind for your family with this range of PIR activated floodlights. Great for the driveway or backyard. All metal construction, fully weatherproof. Must be connected to mains & installed by a licensed electrician.

$52.95 NEW!	$86.95 NEW!	$189 NEW!
X 2340 10W	X 2344 20W	X 2346 50W

Thousands sold to Australia's premier builders!

$39.95ea SAVE 20%

X 2086 Warm white X 2088 Neutral white

Brilliant 9W Genlamp® LED Lighting Kits
Equivalent to a 50W halogen globe with only 1/8th of the power consumption. Complete kit with lamp, gimbal fitting and transformer for an amazing price. These lamps will not disappoint, they have excellent light output, colour and clarity. Ideal for new house installs or plug in replacement upgrades for MR-16 lighting.

35,000hr Sharp® LED	70-90mmØ cutout	60° beam

Creates a central bulk storage on your LAN for all your files.

D 5575

$50 SAVE 15%

Noontec® N5 NAS Gigalink Hard Drive Case
A network attached storage box - simply connects to your LAN and shares files stored in it's internal drive to all your devices. Wired ethernet connection. Hard drive sold separately $149 D 5515 2TB.

Stylish Aluminium LED Desk Lamp

With 3 levels of brightness!

A handy work or reading lamp with adjustable 3-axis boom to get light to where you need it. LED colour temperature has been carefully chosen to replicate daylight with 450 lumen output.

$39.95 NEW!

X 4225

NO MORE EYE STRAIN!

Ultra Bright LED Inspect-A-Gadget.
Ultra-bright long life LED for fantastic clarity (plus no need to change a globe - EVER!). Let "gadget" be your eyes. Identify those impossible to read miniature components without straining your eyes. Great for collectors, model makers, jewellers etc.

$89 TOP VALUE	$99 TOP VALUE
X 4200 3 Dioptre	X 4201 5 Dioptre

$129 NEW!

A 2544

Lightweight, Compact 2 Ch. DJ Mixer
Great for beginners and mobile DJs requiring a robust lightweight mixer. Two pairs of switchable phono and line inputs, plus stereo record and amp outputs. Cue crossfader makes it easy to cue upcoming tracks. Includes power supply.

Handy Gadgets For Less!

Latest Quad Core Arm Cortex A9 CPU

4.2

D 2811

$159 NEW!

Turn your 'dumb telly' into a smart telly!
Smart TVs are all the rage - allowing you to stream movies, music and photos to your big screen, plus access an array of smart phone style games & apps. Simply plugs into a spare HDMI input. Streams 1080p HD video over your home wireless connection. 1GB of RAM, 4GB internal memory, plus micro SD slot.

D 2030

$74.95 NEW!

Amazing sound from such a small unit - just 125mm tall.

It's a phone charger!
It's a Bluetooth® speaker! It's an FM radio!
It's all of the above! A 2200mAH battery bank housed in a blue aluminium case designed to keep your smartphone powered up. It can also playback audio from a micro SD card or FM tuner.

Wireless Desktop Weather Station
A stylish addition to any desk or kitchen counter. Readout shows indoor/outdoor temperatures, humidity, air pressure, weather forecast, moon phase, time & date. Outdoor sensor also shows temperature & humidity. Requires 2 x AA and 2 x AAA batteries.

$49.95 NEW!

X 7026

About the size of a phone!

$50 SAVE 16%

D 0506 6000mAh

$20 SAVE 19%

D 0504 2500mAh

No mains power? No worries!
These mobile battery banks keep your phone or tablet charged up even when you are miles from a 240V outlet. 6000mAh (5V 2A output) or 2500mAh (5V 1A). 5-7hr recharge time. Includes range of adaptors, including Apple 30 pin & Samsung plugs.

Use it at home too!

$28.50 NEW!

A 0309A

Powertran® 4 x USB Multi Travel Adaptor
Enough ports for all your portable devices! 2.1A max current shared between 4 USB ports. Includes adaptors for Australian, US, UK and European outlets. 100-240V ac.

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Top Value Security

Colour TFT Video Door Intercom

• A safe & easy way to monitor the front door • Ultra-sharp 7" colour screen • Records photos of visitors when you're not home • USB/SD photo, video & MP3 playback • Includes power supply, hookup cable, base station & camera unit • Remote door latching* • Expandable to 4 base stations (S 9407) & 2 cameras (S 9409). *When used with optional door strike S 5385 $44.95.

'All In One' DVR & Monitor Unit

4 channel DVR with 7" folding LCD monitor. Provides switching, quad processing and recording functions all in one. Records up to 4 cameras (at 25fps max) to an internal hard drive (sold separately, see D5515). Includes power supply & software.

Professional CCTV Installation Tester

A comprehensive on-site test device for installation and maintenance of CCTV systems. Super light weight handheld design is easy to use up a ladder. In-built LAN cable tester. Full PTZ camera control. Includes charger, adaptors & carry case.

PTZ control
3.5" TFT LCD
RS-485 capture analysis
Focus & aperture control
DC output for power up test

Dual Camera GPS Dashboard Vehicle Recorder

Records footage inside & outside the vehicle simultaneously to the internal 8GB micro SD card. Essential when analysing accidents, driver assaults etc. Audio & video is synchronised with Google maps. Low light CMOS sensor and infra-red LEDs designed for night or day use. **See YouTube video on our website!**

Get more AV gear for your dollar!

Access over 14,000 internet radio stations from your hi-fi!

This stylish wireless internet radio player will perfectly compliment your existing AV system. It provides you with access to DAB+ digital radio stations, plus virtually any internet radio station or podcast via wireless internet (no computer required!). Plus it can stream music stored on your PC via UPnP. Size: 430x90x285mm.

Biema® Stereo Power Amplifier - Excellent Value For Money!

Brilliant performance, producing a smooth, crisp sound with plenty of grunt when required. **Features** • 6.35mm/RCA inputs • Fan cooled • Binding post, 6.35mm & Speakon outputs • Many protection features • Power into 8Ω 2 x 100W, 4Ω 2 x 170W.

Address Large Crowds With Ease

Huge 10" 180W PA driver with USB MP3 playback. An all in one portable PA unit that sets up in just seconds with no expertise required. Just plug into 240V power, switch it on and connect a mic! Versatile, lightweight & built to last. Features: • Bi-amplifier design • 6.35mm/XLR Mic input • RCA line in • Bass & treble • "Daisy chain" multiple units together

Ideal for...
Bingo nights.
Rotary & RSL clubs.
Sports events.
Fetes & carnivals.
Sales demonstrations.

Run HDMI signals over mains power wiring.

This handy problem solver is great for sending 1080p signals from one room to another without the need for any additional cabling. IR repeater allows you to remote control the source device from the other room. 70m range.

Jumbo 4 In 1 Remote Control

• Great for the kids! • Each button is about the size of a 20c coin! • Pre-programmed with 1000's of codes, plus IR learning • Requires 2xAA batteries • Size: 284 x 128mm.

Entertainer Microphone

A superb quality mic housed in a zinc diecast body with a super-cardioid pickup designed to eliminate feedback & unwanted noise. Includes 4.5m XLR 3 pin lead.

5.8GHz Wireless AV Sender

Great for wireless CCTV! • Transmit stereo audio & composite video without cables from room to room • 30m range • IR sender built in • Includes transmitter, receiver & plugpacks.

Wake Up To Digital Radio!

An ideal bedside companion! Wake up to your favourite digital or FM station. Large display with scrolling info. 10 presets. Two alarms.

Great hand tools...

Heavy Duty Ratchet Modular Crimper
With in-built wire stripper & cutter! Rugged all steel construction designed to last a lifetime. A truly pro quality tool for crimping 4 to 8 way modular plugs. Great for making custom data leads.

$119 SAVE $30 — Top of the range!

T 1571

Top Value!

$15 SAVE 25%

T 2187A

Precision Mini Drivers
Contains 5 flat blade and 3 phillips head drivers. Ideal for service technicians. Supplied in a robust carry case.

T 1450

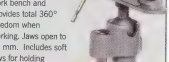
$8 SAVE 19%

T 1460 Magnifier

$10 SAVE 22%

T 1460

Handy Desktop Holders
Just like having an extra hand! Great for gluing, painting or soldering. With or without magnifier.



$17 SAVE 25%

T 1528 1-3.2mm²
T 1527 0.5-2mm²

E-Z Squeeze Wire Strippers
Instant wire stripping with a squeeze of your hand. Jaws have holes to suit various wire sizes.

Nifty Service Aid
Multi-angle mini vice.
Made from diecast alloy. Clamps to your work bench and provides total 360° freedom when working. Jaws open to 55 mm. Includes soft jaws for holding delicate connectors.

Work from any angle. Great for hobbyists!

$32 SAVE 18%

T 2367

Pay less for top quality tools & test gear!

$79 SAVE $20

T 2416

Micron® 45W Digital Soldering Station
An excellent multi purpose soldering iron for service technicians, schools, engineers, R&D, production work etc. Japanese long life ceramic element. 150°-480°C. 0.8mm tip.

Suits lead free soldering	2 Year Warranty	Metal case

Tip has inbuilt LED lamp.

$27.95 NEW!

T 2699

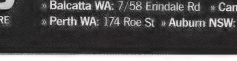
Amazing USB Powered Soldering Iron!
This lightweight unit is perfect for occasional soldering jobs with surprisingly good performance. Includes adaptor for running from a 9V battery and sponge. Fitted with ultrafine tip capable of temperatures up to 896°C!
Check out the YouTube video online.

Regulated precision for voltage critical applications

$239 SAVE $70 — M 8224 3-15V 25A

$429 SAVE $100 — M 8222 1-15V 60A

High Current Regulated Power Supplies
Compact, powerful and lightweight switchmode design. Great for powering communications equipment, car audio amplifiers, camping fridges or other portable DC power appliances.



$119 SAVE $30

X 0109

Clean DVD's, jewellery and small parts with ease.

Shift dirt & grime with nothing but water!
This 70W ultrasonic cleaner is ideal for delicate items such as jewellery, spectacles or car parts. Uses water and ultrasonic waves to clean even the tiniest of items without damage. For best results use T 3180 ultrasonic wash liquid $12.95.

D 3006

$30 SAVE 24% — Easy to use!

Test LAN Cables FAST!
Saves you time and frustration identifying bad network leads! It instantly displays status of all conductors (shorted pins, straight or crossover). Includes battery.

Measure Precisely
Engineer grade stainless steel vernier calipers. Fitted with an easy read dial. Thumb wheel slider and lock. 0.02 to 150mm.

T 2245

$32 SAVE 19%

Q 1121A

$15 SAVE 10%

Protek® 19 Range DMM
Features a data hold function, 3.5 digit jumbo readout, transistor and diode test, 10A max current. Includes test leads, rubber holster.

Great for live venues

Q 1266

$33 SAVE 15%

Pocket Sound Level Meter
A useful tool for tuning high end home theatre & car audio systems. Measures sound up to 130dB. Great for live venues, installers, pubs etc. Includes battery.

Finally a clamp meter designed for electronics use!
The first clamp meter in our range that specialises in low current, high resolution readings down to 1mA. Suits AC or DC use up to 80A. Easy to read backlit LCD. 2 year warranty.

$119 TOP DEAL!

Q 0968

T 2480

$29 SAVE 17% — With refillable cartridge

Reduce Heatshrink Instantly!
Iroda® Pocket sized thermo-gun.
Great for reducing heatshrink, removing adhesives & paint. With a flick of the trigger it instantly powers up to 650°C!

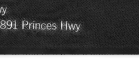
Great for automotive wiring.

$17ea SAVE 11%

W 0884 Colour
W 0886 Black

Handy 160 Piece Heatshrink Pack
A must have for the workbench! 160pc's of 100mm heatshrink in 1.6, 2.4, 3.2, 4.8, 6.4 & 9.5mm sizes.

Adjustable for different surfaces.



Q 1282

$55 SAVE 20%

Contact Free IR Digital Thermometer
...with laser guided beam for pin point accuracy! Professional accuracy for an affordable price. Ideal for measuring whilst equipment is operating. 0.1° accuracy from -20°C to 270°C. Includes batteries.

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» Perth WA: 174 Roe St » Auburn NSW: 15 Short St » Springvale VIC: 891 Princes Hwy

Build It Yourself Kits

Professional Digital-Analog Converter Kit

(SC Sept-Nov '09) This professional quality kit will drastically improve the sound output from your DVD player, allowing you to obtain audiophile quality sound from a regular CD/DVD player, set-top box, PVR or computer. Also reduces buzz, hum and signal noise, ensuring your listening experience is top notch. Coaxial or optical inputs. RCA output. 240V mains operation. Includes screened and punch rack case, all components, transformer, PCBs and cabling.

Silicon Chip 2x20W Stereo Class-A Amp Kit

(SC May-September 2007) Ultra low distortion 2x20W RMS class-A amplifier designed by Silicon Chip. With a THD specification of just 0.0006% it can barely be measured even on pro grade test equipment! A pure Class-A design for audiophiles to enjoy. Includes all components required to construct a fully built amp. **Features:** • 20W output into 8Ω per channel • Amazingly low 0.0006% distortion • On-board remote volume circuit and motorised pot • All metal case - built to last.

TV Pattern Generator Kit

Great for AV installers & service technicians!

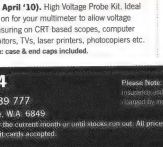
(SC June '06) This compact generator creates 9 diagnostic patterns which are displayed on any device with a composite video input. Requires 9V battery.

Car Diagnostic Analysis Kit

(SC Feb '10). This car interpreter kit connects to your laptop and provides real time readouts from engine sensors (OBD II port vehicles). Ideal for mechanics & enthusiasts.

GPS Boat Computer Kit

(SC Oct '10) Never get lost at sea again! Shows speed and heading - plus it will navigate you back home - or to that secret fishing spot! It even displays fuel consumption, along with a host of other vital information.



Measure 25kV on a standard DMM!

(SC April '10). High Voltage Probe Kit. Ideal add on for your multimeter to allow voltage measuring on CRT based scopes, computer monitors, TVs, laser printers, photocopiers etc. **Note: case & end caps included.**

Digital Audio Signal Generator Kit

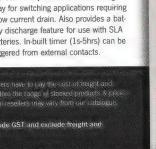
(SC March '10). With S/PDIF coaxial and optical output - plus dual analog outputs! Incredibly low distortion (typically <0.06%). Sine, square, triangle and sawtooth wave generator. Plus waveform mixing, pulse and sweep modes. Ideal for RMS and music power testing; testing DACs & crossovers. Requires 4xAA or 9V plugpack.

Electronic Bellbird Kit

(SC Dec '13) A great starter project for kits to learn about electronics. Mimics the musical sounds of a real Bellbird with a decorative LED chaser light. Includes button cell battery.

PC Birdies Kit

(SC Aug '13) An educational and fun kit to build for electronics beginners. Re-creates the sound of a tweeting Canary at random intervals. Includes Jiffy box case.



Versatimer Switch Kit

(SC June '11) Drives a 12V latching relay for switching applications requiring a low current drain. Also provides a battery discharge feature for use with SLA batteries. In-built timer (1s-5hrs) can be triggered from external contacts.

Resellers

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Somerville	AV2PC	(03) 5978 0007
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Hervey Bay	Ultra Music	(07) 4128 2037
Innisfail	Leading Edge Electronics	(07) 4061 6214
Longreach	Access Electronics	(07) 4658 0500
Rockhampton	Access Electronics	(07) 4922 1058
Toowoomba	Michael's Electronics	(07) 4632 9990
Townsville	SOLEX	(07) 4771 4211
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Cessnock	Leading Edge Electronics	(02) 4990 5971
Cobar	Cobar Electronics	(02) 6836 2962
Deniliquin	Wired Entertainment	(03) 5881 3555
Gloucester	Autolec Gloucester	(02) 6558 1600
Grafton	Downes Electronics	(02) 6642 1911
Griffith	Griffith Systems Plus	(02) 6964 5933
Gunnedah	Protronics	(02) 6742 2110
Lithgow	Leading Edge Electronics	(02) 6352 3333
Nth Richmond	Candle Power Tech.	(02) 4571 4699
Oak Flats	Oak Flats Electronics	(02) 4256 6120
Orange	Fordray Electronics	(02) 6362 9901
Penrith	Penrith Light and Sound	(02) 4733 3333
Port Macquarie	Fettel Comms.	(02) 6581 1341
Smithfield	Chantronics	(02) 9609 7218
Tamworth	Bourke Street Electronics	(02) 6766 4664
Taree	Noeledge Systems Pty Ltd	(02) 6551 3622
Wagga Wagga	Wagga Car Radio	(02) 6925 6111
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Windang	Mad Electronics	(02) 4297 7373
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Findon	Force Electronics	(08) 8347 1188
Kadina	Idyll Hours Hobbies	(08) 8821 2662
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CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.

Adapting an Arduino LCD shield for the MiniMaximite

The popularity of Arduino microcontroller products has spawned many hardware 'shields' which simply plug into the Arduino board. These shields are usually well designed and come with a diverse number of features. They are also normally supported with ready-made software so that getting things up and running is relatively simple.

However, this is not the case for users of the Maximite family who would normally have to design and troubleshoot their own hardware and then write and debug their own software.

This example shows how it is possible for Maximite enthusiasts to enjoy some of the hardware shields developed for the Arduino system. It employs an Arduino LCD Keypad Shield. This has a 16-character by 2-line display which has built-in contrast adjustment and an attractive blue backlight with bright white characters. No extra wiring is required for either.It also comes with six pushbutton switches which can be used as controls.

Many on-line suppliers have these LCD Keypad Shields for $5 to $6 each which is a great deal cheaper than the typical $20 or so charged for a bare-bones LCD panel with no backlight.

The main circuit shows how to connect a MiniMaximite to the LCD shield. I/O pins 13-16, 18 & 19 of the MiniMaximite are connected to pins D4-D7, D8 (RS) and D9 (EN) of the shield. I/O pin 17 is connected to the reset pin on the shield. This assignment allows an 8-way cable to make all these connections. I/O pin 10 on the MiniMaximite connects to pin A0 on the shield, and the ground and 5V supply are connected where shown.

The subsidiary circuits provide the other functions. For example, the circuit at bottom left shows how to control the backlight; all components inside the solid rectangle are already on the shield. I/O 20 on the MiniMaximite connects directly to D10 on the shield to control the backlight. By defining I/O 20 as an open-collector output, its load is the 4.7kΩ resistor. When I/O 20 is high, this resistor turns Q1 on and the backlight is enabled. If I/O 20 is low, Q1 is off and so is the backlight.

Jack Holliday is this month's winner of a $150 gift voucher fro Hare & Forbes

The reset button on the Arduino LCD shield is not used for its original purpose so it can be connected to a digital input and used as an interrupt for the MiniMaximite. The reset button is sensed by I/O pin 17, which is defined as an interrupt pin in the sample program. Note that the 8.2kΩ resistor must connect to the 3.3V supply, not the 5V supply.

Finally, the remaining five buttons on the LCD shield – select, left, down, up and right (these names are generic and serve only to distinguish one button from another) – can be connected to just one analog input (I/O pin 10) to determine which button was pressed.

As before, all components in the pink section are already on the shield board. Only the 5.6kΩ resistor needs to be added. This prevents 5V

Table 1: Button Voltages

Button	Right	Up	Down	Left	Select	None
Voltage	0V	0.45V	1.08V	1.62V	2.31V	3.21V

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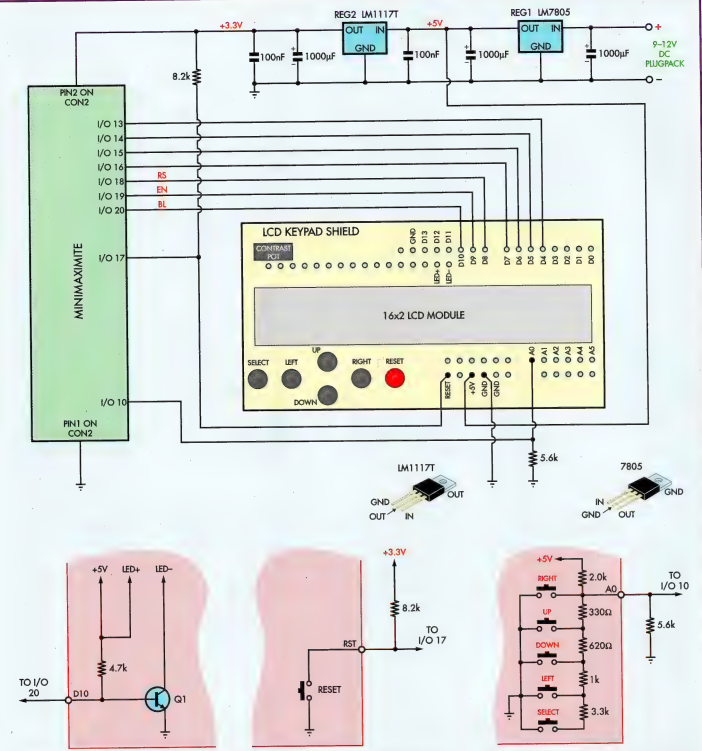


EXPANDED DETAIL OF BACK LIGHT CONTROL

EXPANDED DETAIL OF RESET INPUT BUTTON

EXPANDED DETAIL OF ANALOG INPUT BUTTONS

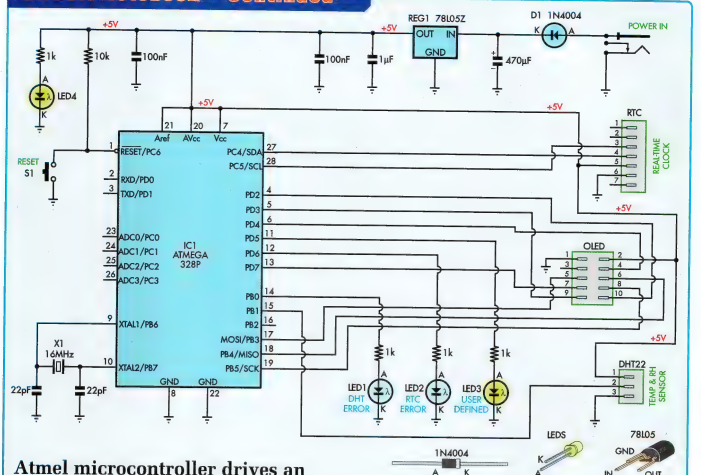
from being transmitted to I/O pin 10 which could damage the MiniMaximite since this input can tolerate a maximum of only 3.3V.

The accompanying table (Table 1) shows the voltages measured when the different buttons are pressed. Using these values with a single ADC input can determine which button was pressed at any given time.

The sample program initialises the LCD, turns the backlight on and gives a welcoming message. It then scans for button presses and branches to the corresponding subroutine for that button.

The subroutines merely announce which button was pressed but can be changed to suit your particular application. The software *lcshield.bas* can be downloaded from the SILICON CHIP website.

Jack Holliday,
Nathan, Qld.



Atmel microcontroller drives an Arduino OLED display

This circuit uses an Atmel ATmega328P microcontroller to record the current time, date, temperature (°C) and humidity (%RH) and feed the information to a 128x128 OLED display available from Freetronics. It uses a Dallas DHT22 sensor for temperature and humidity while using an RTC module for date and time. It also includes several LEDs to display power, errors or a user-defined setting and a 5V regulator for external power.

The indicator LEDs are connected to outputs PD5, PD6 & PB0 which correspond to Arduino pins D5, D6 & D8. The temperature/humidity sensor is controlled by I/O pin PB1 (Arduino D9).

The OLED display is connected to MISO, MOSI, SCK, PD2, PD3, PD7 and Vcc on IC1.

At start-up, the three LEDs (used for errors and user-defined purposes) will flash twice, then a start-up message is shown in 'Arial 14' font. When writing a custom message to be displayed, using \n in the text string will cause text to move to a new line. The program then moves onto the loop where a test of the RTC and DHT22 is performed using 'if' commands. If any errors are present the corresponding LED will light up.

After performing the tests, the loop begins to write to a string called 'writeString'. The first object that is displayed is the time.

First, the program changes the OLED foreground colour to green and clears the string, then the time is added to the string followed by selecting the font, in this case 'Droid_Sans_36', the biggest font on the screen (being the main focus).

When it comes to printing the text to the screen it selects the boundary box to use (selected at the beginning of the code followed by '.print(writeString);'). It then resets the boundary box and moves on to the next object to display. The procedure is then repeated with the boundary box, font and colour changed to suit. For this version the colours and fonts are as follows:

Date: White System Font5x7
Time: Green Droid_Sans_36
Temp: Red Arial_Black_16
Humidity: Royal-blue Arial_Black_16

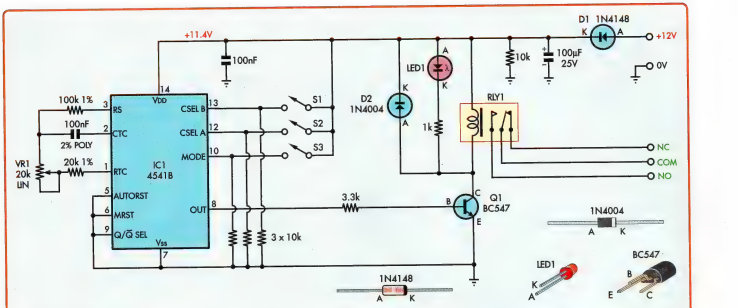
Then there is a 500 millisecond delay and the cycle repeats.

Text colours, foreground colour, font and position can be changed to suit the user.

Note that the OLED module is subject to image "burn-in", similar to that experienced on plasma displays when static images are present for many hours. This can be avoided by regularly changing the position of the image on the screen.

The code is written in the Arduino IDE and uses 31,812 bytes of data from a total of 32,256 bytes. This does not allow a lot of room for any additional code. The software, OLED_TTHD_RV3.ino, can be downloaded from the SILICON CHIP website.

Jed Hodson,
Galong, NSW. ($75)



Versatile timer is based on a single chip

This timer uses a 4541 programmable CMOS 16-stage binary timer chip which is also featured in the Precision 10V Reference on page 44 of this issue. Readers may find it useful to compare these circuits which provide quite different functions.

In both cases, the internal oscillator is employed and its frequency is set by the components connect to pins 1, 2 & 3 and it can varied over a wide range with potentiometer VR1. Three switches are connected to pins 10, 12 & 13 and these could be in the form of links or a 4-way DIP switch.

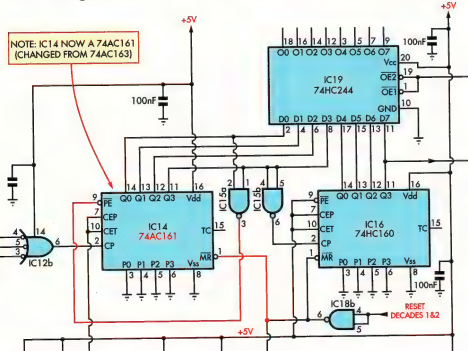
Counting starts when power is applied. The switch at pin 10 defines whether the timer runs for just one cycle when grounded or continuously when switched high. The switches at pins 12 & 13 select the number of internal counter stages and therefore the length of the timer cycle. With both these pins grounded (switches open), 13 stages are selected and it counts to 8192. With pin 12 high (switch closed) and pin 13 low, 8 stages are selected and it counts to 256. With pin 12 low and pin 13 high, 10 stages are selected and it counts to 1024. And finally, with both pins 12 & 13 high (both switches closed), all 16 stages are selected and it counts to 65,536.

Pin 8 goes high at the end of the cycle and turns on transistor Q1 to energise the relay which has a set of changeover contacts (ie, single-pole, double-throw – SPDT) and it also lights LED1.

The circuit is powered from a 12V DC source but this could be changed to 6V if a 6V relay is used.

Michael Azzopardi,
Taylors Hill, Vic. ($35)

Last digit bobble fix for 12-digit frequency counter



This add-on circuit was devised to overcome the problem of last digit "bobble" on the 12-Digit Frequency Counter (SILICON CHIP, December 2012 & January 2013) which was discovered by Peter Urban (Mailbag, page 10, November 2013). At that time, a software fix was devised to cure the problem but for those constructors who may have difficulties upgrading the software, this circuit replaces IC14, a 74AC163 with a 74AC161 and swaps the connections to pins 1 & 9.

To do this without cutting any tracks, simply bend up pins 1 & 9 of the 74AC161 before it is installed and then use two short insulated wires to connect pin 1 to the pin 9 hole and pin 9 to the pin 1 hole. On the 74AC161, pin 1 is Master Reset (bar) and requires no clock pulse to clear the chip.

Graham Lill,
Lindisfarne, Tas. ($60)

Building our new Super Smooth, Full-range, 10A/230V Speed Controller for Universal Motors

Last month we described the features and circuit details of our new Speed Controller. This month we move on to construction and troubleshooting.

Part II – by John Clarke

This new Motor Speed Controller supersedes the one we published in May 2009. We no longer recommend that circuit because this new design provides much smoother operation and also has much better overload protection.

It is constructed on a single PCB coded 10102141 and measuring 112 x 141mm. It is housed in a diecast metal case measuring 171 x 121 x 55mm. A front panel label measuring 168 x 118mm is attached to the lid of the case.

The PCB includes cutouts to match the shape of the case and a cutout for the IEC input connector.

Before construction, you need to check what bridge rectifier is being used for BR1. This can be either a PCB mounting type or one that has spade terminals – the construction varies depending on which type is used. There is no best choice.

For the spade terminal bridge extra wiring is involved whereas with the PCB mounted bridge, there is some filing required to remove the two ribs that prevent the bridge mounting flat against the side of the case.

Also decide if you prefer having the feedback control potentiometer (VR2) mounted on the front lid or whether you will use the internal trimpot (VR3).

Beginning construction

First of all, check the PCB for any etching problems (bridged or broken tracks, etc) and wrongly-drilled holes.

This is NOT a project suitable for beginners or the inexperienced!

This project should only be attempted by constructors with extensive experience in mains-powered circuits and with the knowledge necessary to get it going if something is wrong.

This circuit connects directly to the 230VAC mains and most components are floating at this voltage.

Inadvertent contact with a live circuit could prove lethal.

Do not operate the circuit with mains connected, without the case lid being secured with all six screws provided. Always remove the mains lead from the IEC socket before removing lid.

Low-voltage trouble-shooting tips are provided later in this article.

But we must reiterate: do not attempt to build this speed controller if you do not have the experience necessary to do so.

We do not expect that there will be any problems with PCBs supplied by the SILICON CHIP OnlineShop or with those supplied in kits. These are of high quality and are solder masked, screen-printed and shaped with the required cutouts.

However, if there are any problems, repair these as necessary. Similarly, if the cut outs in the sides of the PCB have not been shaped, they should be cut and filed before any components are assembled.

Check that the PCB fits into the case before starting assembly.

Following the overlay diagram shown in Fig.9, first solder in the resistors, except the 0.01Ω resistor, using the colour code table on page 92 and/or a digital multimeter, to ensure you have the right resistors in the right places.

When inserting diode D2 and ZD1 take care with their orientation. Diode D1 is installed later.

We use an IC socket for

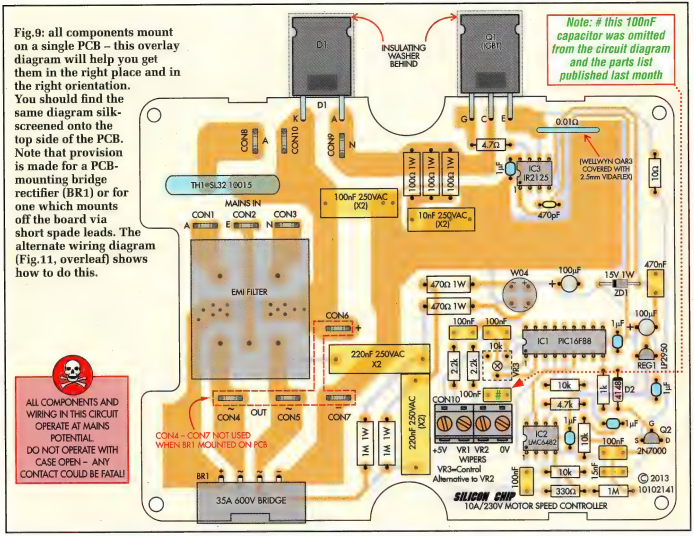


Fig.9: all components mount on a single PCB – this overlay diagram will help you get them in the right place and in the right orientation. You should find the same diagram silk-screened onto the top side of the PCB. Note that provision is made for a PCB-mounting bridge rectifier (BR1) or for one which mounts off the board via short spade leads. The alternate wiring diagram (Fig.11, overleaf) shows how to do this.

IC1 only. Be sure to install the IC socket and the ICs the correct way around with the notch facing the direction shown on the overlay. Also, ensure IC2 and IC3 are placed in their correct position. REG1 and Q2 can now be inserted, again taking care to place each in its correct position. Q1 is installed later.

Capacitors can be installed next, again using the capacitor table. It shows the various codes that are used to indicate the capacitance values of the MMC, MKT polyester, and ceramic capacitors.

The electrolytic capacitors have their value directly marked but must be oriented with the correct polarity, as shown, as must the small diode bridge, BR2, which can be soldered in now, along with the 4-way screw terminal.

It's made up of two 2-way terminals dove-tailed together before being inserted and soldered in place. The lead entry side is toward the lower edge of the PCB.

The 0.01Ω resistor can now be installed. It has a 40mm length of 2.5mm diameter Vidaflex heat resistant sleeving slid over it before inserting into the PCB holes.

Features

- For 230VAC brush (universal) motors
- Extremely smooth and precise motor speed control
- Speed can be controlled from zero to maximum
- Superb speed regulation under load
- Adjustable speed regulation with feedback control
- Excellent low-speed motor operation
- 2300W (10A) rating
- Cycle-by-cycle current overload protection
- Over-current limiting
- Soft starting
- NTC Thermistor for initial surge current limiting
- Fuse protection
- Rugged case with interference suppression included

VR2/VR3 choices

As discussed last month, VR2 is optional but gives front-panel control over feedback. Note that if VR2 is going to be used, you should include either VR3 or a link in its place on the PCB to prevents input AN3 from floating.

Solder in VR3 or place a short wire link (using a length of resistor lead off-cut) between the central wiper connection and one of the end pads (either one) for the VR3 position.

Next are the spade connectors at CON1-CON3 and CON8 & CON9. Spade connectors are also required at CON4-CON7 if BR1 is a spade terminal type.

Install the EMI filter and also the NTC thermistor. The PCB-mounted bridge for BR1 can be mounted now if this is used. This sits as low onto the PCB as possible before being soldered in place.

D1 and Q1 are the last components to be soldered to the PCB. Solder them in so their metal flanges are towards the edge of the PCB and their full length leads extending about 1mm below the PCB.

Mounting the hardware

The front panel artwork can be copied and used as a marking-out template. Note that it does not have a hole position for the main earth bolt, which can be mounted anywhere it doesn't interfere with anything else.

Also shown is a marking-out diagram for the end wall of the case (Fig.12).

Jaycar's MS-4000 EMI filter mounts directly on the PCB and assists greatly in removing switching noise generated by the circuit.

The IEC connector mounts with about 4mm gap from the base of the case to the bottom of the IEC connector. The hole is made by drilling a series of small holes around the perimeter of the desired shape, knocking out the piece and filing to shape. The earth screw hole is 4mm in diameter.

If you are using the PCB-mounted bridge rectifier, file away the two ribs on the side of the case that prevent the bridge mounting flat.

Insert the PCB into the case noting that the leads for D1 and Q1 must be kinked outward a little so that the metal flange of each device is parallel to and in contact with the side of the case. Mark the mounting hole positions for diode D1, IGBT Q1 and bridge rectifier, BR1.

For the quick connector terminal bridge rectifier type, this is mounted side on against the case side.

Holes required for mounting Q1

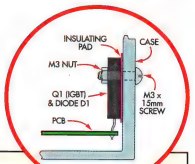
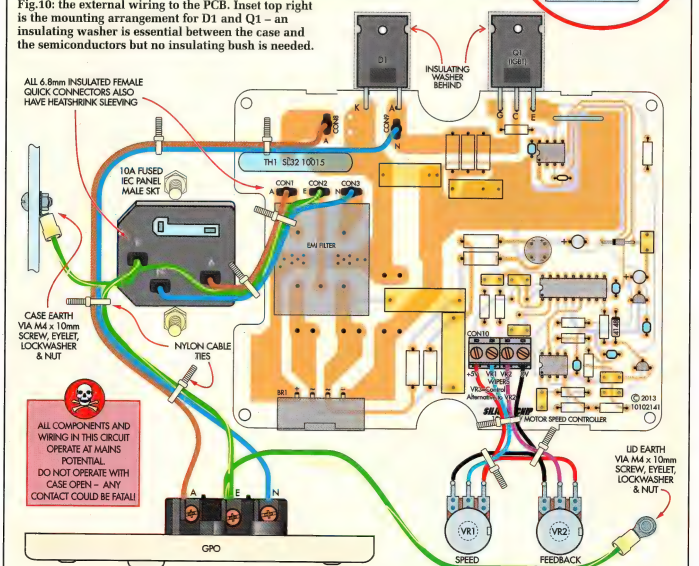


Fig.10: the external wiring to the PCB. Inset top right is the mounting arrangement for D1 and Q1 – an insulating washer is essential between the case and the semiconductors but no insulating bush is needed.



and D1 are 3mm, while a 4mm hole is required for the bridge rectifier.

Holes are also required in the lid for VR1 and VR2 (if required) and the earth terminal, with a cutout and holes for the mains general purpose outlet (GPO).

There are locating spigots on both VR1 and VR2 which prevent the potentiometer body from rotating when the knob is turned. The holes for these (so the spigot will be captive in the hole.) do not need to be drilled fully through to the front of the lid panel.

All holes should be de-burred on the inside of the case with a countersinking tool or larger drill to round off the sharp edges. For D1 and Q1, the edges must be rounded to prevent punch-through of the insulating washers.

Attach the PCB to the case with the two supplied screws with the case plus an extra two M3.5 x 6mm screws.

Secure D1 and Q1 to the case with a screw, nut and silicone insulating washer. No insulating bushes are necessary as the packaging of D1 and Q1 have insulation between the mounting screw hole and metal face.

The arrangement for this is shown in the inset in Fig.10. After mounting D1 and Q1, check that the metal tabs of the devices are isolated from the case by measuring the resistance with a multimeter. The meter should show a very high resistance measurement between the case and any of the diode and IGBT leads.

Here's a close-up of the mounting for the IGBT (Q1) with its insulation washer underneath. Diode D1 is similarly mounted. The cambric insulation at top right covers the 0.01Ω resistor

The complete wiring diagram is shown in Fig.10. The earthing details of the case are most important since the IGBT, D1 and the potentiometers, VR1 and VR2 are all at 230VAC mains potential yet are attached to the case. If the insulating washers or the insulation of a potentiometer were to break down, the case would be live (ie, at 230VAC) if it was not properly earthed. For the same reason, the case lid must also be independently earthed.

The bridge rectifier (BR1) is secured to the case with an M4 screw and nut. It does not require an insulating washer between its body and the case.

Cut the potentiometer shafts to length to suit the knobs. Then install the potentiometers. These are mounted with up to two washers between the pot and the lid for the locating spigot to fit neatly into its locating hole. Fit knobs to the shafts. The central pointer on each knob may require prising out and relocating to the correct orientation.

All mains wiring must be done using 10A 250VAC rated wire. Wiring for the potentiometer must also be mains rated but it does not need to be 10A rated. The IEC connector must be wired using the correct wire colours (brown for Active, blue for Neutral and green/yellow striped wire for Earth). Use quick connectors for the mains wiring connection to the PCB connectors. Wires to the IEC connector need to be insulated with heatshrink tubing covering all exposed metal terminals for the Active and Neutral wiring.

For earthing, solder two earth wires from the IEC connector. Each wire should loop through the hole in the earth terminal and be wrapped back on itself so the wire is essentially captured before soldering to the terminal.

Make sure the earth terminal is heated sufficiently with the soldering iron so the solder wets and adheres properly to both terminal and wire. One end of the earth wire is crimped to the earth eyelet and the other to the GPO earth terminal and the earth eyelet on the lid. It is important to use one continuous earth wire length with just the insulation stripped back in the middle to terminate into the GPO earth screw terminal.

The earth eyelets are secured with M4 screws, a star washer and nut, with

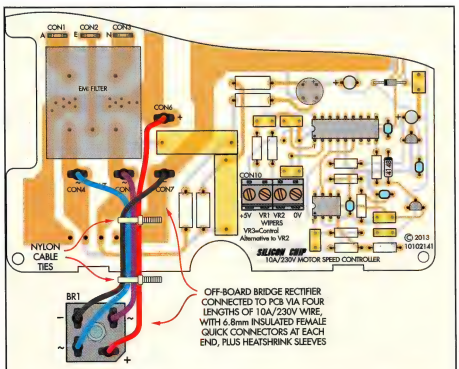


Fig. 11: if your bridge rectifier (BR1) is designed for off-the-PCB mounting, here's how to wire it. You'll need to make up some short spade-lug leads.

The view inside the completed project. Note that there is no power lead connected to the IEC socket in this picture – the case should never be open with power applied!

a second nut used as a locknut. Note that a countersunk screw is used on the lid. The IEC connector is secured with the M3 x 10mm countersunk screws, star washers and nuts. Similarly, the GPO is secured with M4 screws, star washers and nuts.

Wire up the potentiometer, again using 250VAC-rated wire. The reason for this voltage rating this is to ensure that there is no insulation breakdown to case. Finally, hold the wiring in place using cable ties as shown. This minimises the possibility of any wire breaking loose and making contact with the case.

Capacitor Codes

Value	µF value	IEC code	EIA code
470nF	0.47µF	470n	474
100nF	0.1µF	100n	104
15nF	.015µF	15n	153
10nF	.01µF	10n	103
1nF	.001µF	1n0	102
470pF	NA	470p	471

All "X2" class will have printed values

Testing

Before you power up the circuit, check all of your wiring very carefully against the overlay and wiring diagram. Also check that the case and lid are connected to the earth pin of the power socket.

If you are satisfied that all is correct, you are almost ready to screw the lid onto the case. Set VR1 and VR2 fully anticlockwise. If you are not using VR2, set VR3 anticlockwise instead.

When screwing the lid on, note that the case is supplied with a rubber seal that goes around a channel in the lid.

Do not be tempted to operate the speed controller without the lid in place and screwed in position.

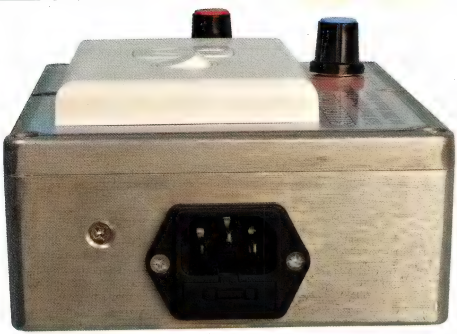
Any delving into the circuitry when it power is connected is potentially lethal. Preferably, use an earth leakage circuit breaker (safety switch) on the mains supply. If there isn't one already installed in your fuse box, use an in-line type.

The easiest way to test the circuit operation is to connect a load such as a standard (ie, non-speed-controlled) electric drill. Apply power and check that you can vary the drill speed with VR1. Some motors may require adjustment of VR2 for best speed regulation. If using VR3 instead this must be done on a trial-and-error basis with the power off. Disconnect power to the controller by unplugging the IEC mains power lead from the mains wall outlet, adjust VR3 very slightly and replace the lid.

In practice, if VR2 or VR3 is adjusted too far clockwise, the motor may tend to be overcompensated when loaded

Resistor Colour Codes

No.	Value	4-Band Code(1%)	5-Band Code (1%)
3	1MΩ	brown black green brown	brown black black yellow brown
3	10kΩ	brown black orange brown	brown black black red brown
1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
2	2.2kΩ	red red red brown	red red black brown brown
1	1kΩ	brown black red brown	brown black black brown brown
2	470Ω	yellow violet brown brown	yellow violet black black brown
1	330Ω	orange orange brown brown	orange orange black black brown
3	100Ω	brown black brown brown	brown black black black brown
1	10Ω	brown black black brown	brown black black gold brown
1	4.7Ω	yellow violet black gold (5%)	n/a



The end of the diecast case must be drilled and filed to house the fused IEC mains input socket along with a countersunk 4mm hole for the main earth bolt (see diagram below).

and will actually speed up. It may even hunt back and forth between a fast and slow speed. If this happens, readjust VR2 or VR3 anticlockwise for best results.

If you are using a drill at fairly low speed, the motor should not slow down by much as you put a reasonable load on it.

Note that the feedback feature where the idle current can be dialled out will prevent the motor speed from increasing with increasing feedback control adjustment. The idle current can be dialled out by running the motor at the desired speed and then rotating VR2 anticlockwise so that the controller measures the idle current.

Then readjust VR2 clockwise to its required position for best control. The motor speed is then only controlled for current that exceeds the idle current. This feature cannot be easily activated using VR3.

This speed controller must NOT be used with appliances that already have a continuously variable speed controller built into the trigger.

You **can** use the speed controller with electric drills that have two-speed gearbox switching (ie, non-electronic) speed control.

One final point; if you are using this controller with a high power tool such as a large circular saw or 2HP router, it will not give the same kick when starting. That is because of the soft start – the motor will take slightly longer to come up to full speed. This is due to both the NTC thermistor and PWM soft start by the micro.

Troubleshooting

If the speed controller does not work when you apply power, it's time to do some troubleshooting. First, a reminder: all of the circuitry is at 230VAC mains potential and can be lethal. This includes any exposed metal parts on components except those that are tied to the earthed chassis of the case. Do not touch any part of the circuit when it is plugged into a mains outlet. Always remove the plug from the mains outlet before touching or working on any part of the circuit. Before going any further, check the fuse, then give your PCB another thorough check (using a magnifying glass?). Check for incorrectly placed components and for component orientation. Also check solder joints.

Fortunately, there is a safe way to check most of the circuit and that is to operate it from a low voltage (12-14V with at least a 20mA current capability) DC supply.

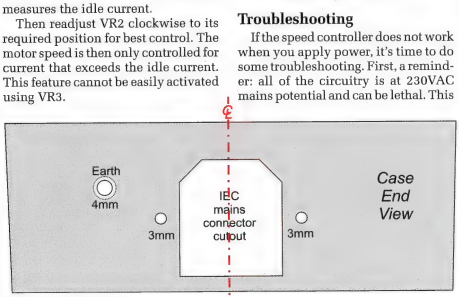


Fig12: drilling detail for the end of the case shown above. Photocopy this and stick it to the end of the case, then drill right through it.

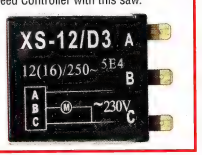
Tools with "Soft Start" Circuits

When testing the 230V 10A Brush Motor Speed Controller on a 220-240VAC 6.5A Makita LS1017L Sliding Compound Saw, the motor would not operate at all. A quick search on the 'net revealed that this saw includes a soft start circuit to prevent the otherwise massive surge current at start up.

Presumably, the soft start circuit requires an AC supply in order to work. The full wave rectified DC voltage from the Motor Speed Controller prevents it working.

The accompanying photograph shows the soft start module. This is located just inside the end cap of the motor where it receives cooling air drawn in through the motor fan.

The C terminal connects to mains Active via the trigger on switch for the saw. The A terminal connects to mains Neutral. The soft start connection is between terminals A and B. By disconnecting the soft start A & B terminals then bridging the spade lugs which originally connected to them, we were able to use the Motor Speed Controller with this saw.



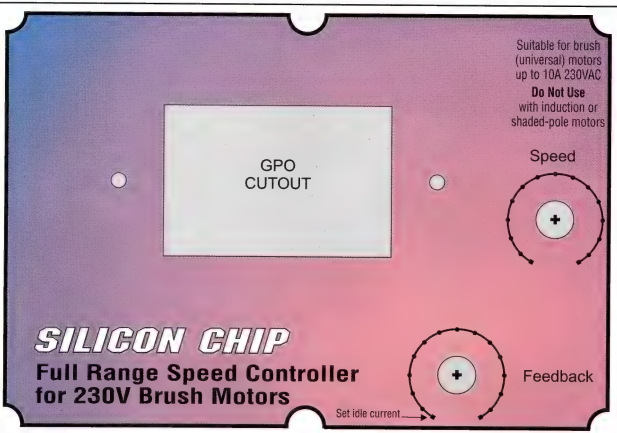


Fig.13: this same-size front panel label can also be used as a drilling/cutting template as well as the final label – if you want it in colour, it can be downloaded from siliconchip.com.au and printed on a colour printer. The 4mm countersunk hole for the lid earth screw is not shown – it can go anywhere it doesn't interfere with controls, etc. When applied, the label hides its location.

Remember that most plugpacks supply significantly above their rated voltage when unloaded so we would always err on the lower side, ie, 12V rather than 14V.

You must have the 230VAC mains disconnected from the controller by unplugging the IEC mains lead from the controller and the mains socket.

The supply is connected to zener diode ZD1 with the positive connecting to the cathode (striped end) and the negative connecting to the anode. Before you connect the supply, measure it to make sure it is not exceeding 14V, otherwise you may damage the 15V zener diode.

A multimeter can be used to test voltages with the negative lead to the negative supply (anode of ZD1). Firstly, check that there is supply at both pin 1 & 8 of IC3, This voltage should be the same as your power supply connection.

Pin 14 of IC1 should be about 5V (4.85 to 5.15V) as should pin 8 of IC2. Voltage on the wipers of VR1 and VR2 should be adjustable from 0V to 5V when rotating the potentiometer to its full extremes. Pin 6 of IC2b should be 3.4V.

Pin 9 of IC1 should be adjustable from 0V to 5V as VR1 is adjusted over its full range. This is a DC measurement of the PWM signal. Pin 7 of IC3 should range from 0V through to the power supply voltage with VR1 adjustment. A similar voltage range will be available on the gate of Q1. If the gate voltage remains at 0V, then suspect a damaged IGBT or a short from gate to ground.

If your meter can read frequency, the PWM signal at pin 9 of IC1 should give a reading of 980Hz when VR1 is around mid setting. You will not get a frequency measurement with VR1 set at either extreme end of its rotation.

Measuring the resistance between IGBT pins is a simple way to check this component. If there is a short circuit between collector and emitter, or if the gate is shorted to the emitter, then the IGBT is likely faulty unless there is a short on the PCB instead.

Diode (D1) operation can be checked using the diode test on your multimeter - there should not be a short circuit between anode and cathode.

Be sure to remove the power supply connection and replace the lid before reconnecting to the mains.

If the live circuit must be worked on, it must be operated via a 1:1 mains isolation transformer and having an earth leakage circuit breaker (safety switch) installed.

Incidentally, do not try to monitor the waveforms with an oscilloscope when powered from the mains unless you know exactly what you are doing. Ideally it needs with a scope with true differential inputs or a mains isolation transformer.

And a final warning!

The entire circuit of this motor speed controller floats at 230VAC. It is potentially lethal. Do not build it unless you know exactly what you are doing. Do not touch any part of the circuit while power is applied from the mains and do not operate the circuit outside its metal case or with its lid off.

This circuit is not suitable for induction motors or shaded pole motors such as those used in fans. SC

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PRACTICAL VARIABLE SPEED DRIVES & POWER ELECTRONICS by Malcolm Barnes. 1st Ed, Feb 2003. $73.00

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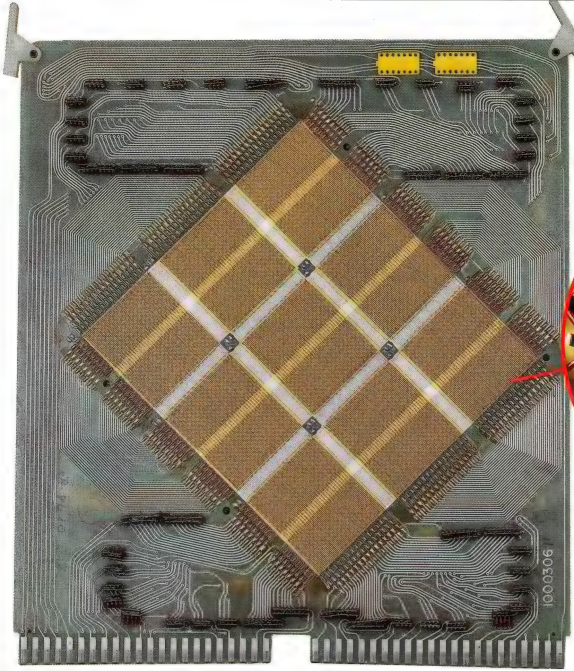


Actual size of this 1974 core memory "card" – 245 x 280mm – is a little larger than this page. Capacity is a whopping (for the time!) 4KB x 9 bits and it consists of 36,864 of the tiny ferrite beads enlarged in the inset below.

By contrast, here's a modern 4GB memory card – one million times more capacity – shown at about the same scale (it's actually 15 x 11mm)! The latest iterations of this card offer up to 256GB of memory.

CORE MEMORY

While cleaning up the garage, I came across this 40-year-old ferrite core memory module, removed from a Mohawk MDS2400. Its capacity is 4KB (of 9 bits). In these days of hundreds of gigabytes of memory in cards no bigger than your fingernail, I wondered how many SILICON CHIP readers would have ever seen this type of memory, or even seen a 'bit' in its rawest form.

By Brian Armstrong Photos by Geoff Barton

Here's the type of equipment this core memory card came from, the Mohawk MDS2400. This is actually a 1975 model, even later than we've been talking about – but is typical of the era (where are the dudes with the white dustcoats?). The most amazing part of it all is that your pocket calculator probably has more computing power and memory than this room full of equipment.

In 1974, one of these 4K cards, or panes, would have set you back around $4500. Given the average Melbourne house price in 1974 was about $25,500, it gives you some idea of their value. In 2014 dollars, think somewhere north of $100,000 per card and you're not far wrong!

Apart from their physical construction, there are two fascinating aspects of core memory. One is that it is non-volatile (ie, it holds memory when powered off) and two, you can actually see it. Bit by bit!

Companies could also supply and ship core memory pre-programmed.

I worked on mid-range servers and accounting machines in the eighties, which used both core and MOS memory.

When I think back, I also remember working on the old CDC 14-inch drives, which had a fixed and removeable platter and were a total of 20MB (yes, that's written correctly – 20MB, not GB) in capacity.

Those days, we also fixed a majority of the items to component level, and aligned servo and data heads on the disk drives with an oscilloscope and an Allen key.

I will never forget this, as the alignment was such a fine adjustment that if you moved it too fast, the heads would do an emergency retract, then scare you as they nearly took off your hand at the same time.

What is core memory?

Core memory, or more properly ferrite core memory (but sometimes referred to as magnetic memory), was first developed during the late 1940s and early 1950s.

Some references claim this was part of the "Whirlwind" computer project at MIT; others state that An Wang (of Wang Computer fame) was responsible while working at the Harvard Computing Laboratory.

As late as the 1970s, equipment was still being made which used a form of core memory. It was renowned for its reliability but was very expensive to build, as it is based on thousands of tiny ferrite cores with (normally) three wires passing through every one.

When magnetised, each core held a single bit as a 0 or 1, based on the direction of the magnetic flux around the core (clockwise or anti-clockwise, respectively).

The magnetic orientation was changed by current running through the core in a particular direction. This current was controlled by an arrangement of "X" and "Y" wires, both of which passed through the core.

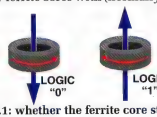


Fig.1: whether the ferrite core stored a "0" or "1" depended on its magnetic flux, which in turn depended on the direction of the current pulse that was originally sent through it. Once magnetised, the core maintained the memorised state almost indefinitely, even if power was removed.

Two half-strength pulses

The way a particular core was selected was to send a half-strength

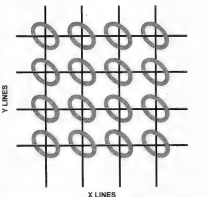
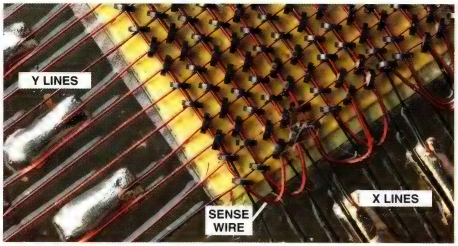


Fig.2: the magnetising was actually controlled by two wires, each being fed half the current required to magnetise the core. When two energised wires passed through a core, the currents added and the core was magnetised.



In this extra close-up, you can clearly see the X and Y lines passing through their rows of ferrite beads, along with the sense wire passing through all the beads. Pairs of beads were oriented so that, as far as possible, they were opposite to their neighbours to minimise the chance of magnetic interference.

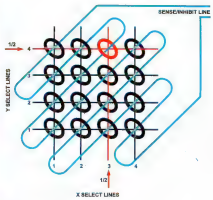


Fig.3: an additional wire which passed through all cores sensed any change in the cores and identified the bit state of the changed core. This sense wire can be seen through some of the cores in the enlargement pic above left (the blue wire). In most cases it's hidden underneath.

pulse down the relevant X wire and a corresponding half-pulse down the Y wire.

Half-strength currents were not enough to fully magnetise the core but the coincident-currents of both lines would be enough to then fully magnetise the targeted core and change that bit's magnetic flux direction accordingly.

Putting this simply, only where these wires intersected, would the total amount of current be enough to magnetise the polarity of that bit. All others would not be impacted as they would either not receive a pulse, or only a half strength pulse if in the same X or Y lines.

Once a core was magnetised with sufficient current, the magnetic properties were so strong that they would hold there almost permanently, just like a normal magnet, until "re-written".

Sense wire

Core memory also had an additional 'sense' wire that ran through all cores in the same pane (window). This was used to read (sense) magnetic properties to identify the bit state.

In early core memory, another separate wire, called the inhibit line, was also used when multiple panes were interconnected.

The inhibit line would be used when multiple panes of memory were connected together to save X/Y selection lines.

This was performed by joining all corresponding X lines together, and all corresponding Y lines together, then selecting the individual pane by enabling a reverse current on the inhibit line on all other panes. This effectively dropped the current on the ones not required to a point where the core would not be magnetised.

Later releases of core memory incorporated the inhibit and sense functions in the same wire as they were used at different times.

To read a single bit of core memory, the circuitry attempted to flip the bit to whatever polarity the machine regarded as a 0 state, by driving current down the selected X and Y lines that intersect at that core in one direction. (See Fig.3).

If the bit was already 0, the physical state of the core was unaffected and no change pulse was received on the sense line.

If the bit was previously 1, then the core changed magnetic polarity. This change, after a short delay, induced a voltage pulse into the 'sense' line.

This is due to the hysteresis of the core material. It's like a light globe: if it's off and you apply power (change state), there's an initial spike due to the extra power on current.

However, if it was already on, and you applied the same power, then no extra current would be required and therefore no spike. Although not quite the same, it was a simple way to think of it operationally.

Detecting the pulse meant that the bit contained 1. Absence of the pulse meant that the bit contained 0. The delay in sensing the voltage pulse is called the access time of the core memory.

Following any such read, the bit was set to 0 regardless of its original state, which is why core memory had the term 'destructive reads': An operation that reads the contents of a core, erasing the contents while doing it. (see Fig.5).

This is also why it was immediately followed by a write, which would reset its original state if found to be a one.

This ensured that the initial state of the memory was not changed by reading it, as long as power was not interrupted immediately following the read operation (see Fig.6).

To write a 1 bit, the required X and Y lines were pulsed with current in the opposite direction of the read operation. As with the read, the core at the intersection of the X and Y lines changed magnetic polarity. This then magnetised the corresponding core, in the opposite direction (see Fig.4).

For multiple panes configured in word arrangements, each corresponding pane row was connected to the next and each corresponding pane column connected to the next.

A zero was then accomplished by using the inhibit line. To write a 0 bit (in other words, to inhibit the writing of a 1 bit), the same amount of reverse direction current was also sent through the Inhibit line. This reduced the net current flowing through the respective core to half the select current, inhibiting change of polarity on that pane.

The access time plus the time to rewrite is the memory cycle time.

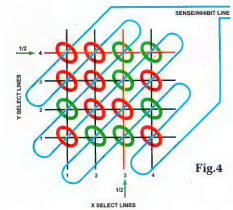


Fig.4

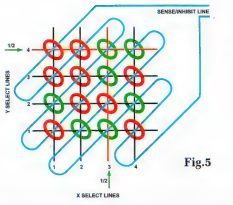


Fig.5

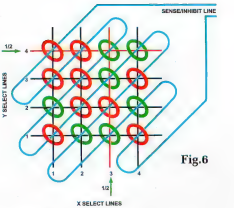


Fig.6

Fig.4 (left) shows the initial state of a sample memory address. Notice in this scenario address X3:Y4 state=1. This was previously selected by driving half current down theX3 line and half current down the Y4 line in a 1 state polarity. Green=1, Red=0. Fig.5 (centre) shows a destructive read. Address X3:Y4 is sent half current zero state polarity down the Y4 line and another half down the X3 line. As the bit was effectively 'flipped', where the state changed from a 1 to 0, a delayed pulse is received on the Sense line. The sensing circuitry then knows that the read state was initially a one. Had the initial state been a zero, there would be no change and therefore no sense pulse. Fig.6 (right) shows a write after the read in Fig.5. In this scenario, the bit is set back to its initial state of 1. A pulse on the sense line will also be received after the change as confirmation, as the bit flipped back.

It sounds strange to comment on now, but I do remember when I have seen people repair memory at times. This was normally caused by a dry joint, or by dropping the actual PCB and dislodging parts.

A magnifier was required, along with special tools. The first magnetic cores were also much larger than the ones pictured. The layout of each core was also paramount to stop interference between them.

Core memory and "core" chips

Who could have imagined then, that miniscule integrated circuits would be created that could replace these that were massively larger in capacity or even today, where the complete memory chip can basically detect and repair bad reads itself (EDAC) and be a complete throwaway on failure – at a cost of a cup of coffee!

While the names might be the same, magnetic core memory and modern "core" chips have virtually nothing in common – for a start, core chips are microprocessors, not memory. The still-used term "core dump", though, does have its origins in ferrite core memory, where all contents were erased by a special command.

Some may say that we do not need to know the finer details of 'what's inside' but I am sure that a majority of readers would have opened a working electronic device, just to see how it worked.

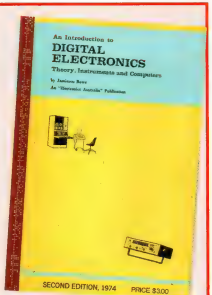
Whether they ever got it back together again – and it worked – well, who knows! SC

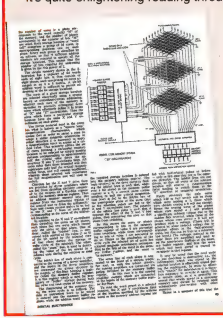
DIGITAL ELECTRONICS – circa 1974

We couldn't resist making mention of this authoritative reference book, written by our own Jamieson Rowe, first published as a series in "Electronics Australia" during the late 1960s and then reprinted in several editions up to the mid 1970s.

The field of digital electronics was still, if not in its infancy, a very young child and Digital Electronics, the book, was used by many universities, TAFE colleges and trade schools as a major textbook for students cutting their teeth on matters binary, programming and the still black science of computers and computing.

It's quite enlightening reading through this book to see what was then "state of the art" in equipment – including a detailed description and analysis of Ferrite Core Memory (on page 85).





It's right up there with Fortran, Cobol and Algol, with punched cards, with drum memories and PDP/8 computers! Even Cathode Ray Tube monitors were described as a recent invention. . .

While now out of print for a few decades, the principles and theories explained in Digital Electronics still hold good even today, even if techniques and equipment have long been superseded and consigned to history, seen only in museums and in nostalgic articles, as the one presented here by Brian Armstrong.

Vintage Radio

By Dr Hugo Holden

The 1956 Sony Gendis TR-72 Transistor Radio

One of the earliest transistor radios on the market was Sony's TR-72. This was a high-quality design employing seven NPN transistors and housed in a very attractive timber cabinet.

THE TRANSISTOR RADIO era began in 1954 when the world's first commercially successful transistor radio, the American made Regency TR-1, was released (see Vintage Radio, April 2013). Very shortly afterwards, transistor radios from a plethora of manufacturers appeared on the market.

One such company, the Tokyo Tsushin Kogyo company of Japan (Sony), was hot on Regency's heels, bringing their TR-55 to market in 1955. They then followed up with the TR-72 7-transistor radio in early 1956.

It's interesting to note that the transistor had been invented just a few years before, in 1948 at Bell Laboratories by Bardeen, Brattain and Shockley. So there was only a modest delay before manufacturers came up with a major practical commercial application for these devices.

Early transistor problems

Early transistors suffered from a high collector-to-base capacitance. This is generally referred to as "Miller capacitance" and the negative feedback induced by this has the effect of progressively lowering the transistor's gain (or amplification) as the frequency increases. This makes such transistors useless as radio frequency amplifiers unless special precautions are taken.

In addition, if there is a tuned circuit of similar frequency in both the base and collector circuits (ie, in a grounded emitter amplifier), then the amplifier could oscillate. That's because the Miller capacitance can result in regenerative rather than degenerative feedback, especially when the two resonant circuits have similar frequencies. The Miller capacitance in this instance allows the two tuned circuits to exchange energy with each other and oscillation and instability can occur.

The Miller capacitance also reduces the input-output isolation of a transistor acting as a grounded emitter amplifier and it does the same thing to a triode in a grounded cathode amplifier configuration where it acts between the plate and the grid. Pentode valves don't have this problem because their screen grid provides input-output isolation.

The technique used to avoid the Miller capacitance problem is known as "neutralisation". This involves feeding an out of phase signal from the output (usually derived from an IF transformer or tuned transformer winding) back to the transistor's base to phase cancel the current from the Miller capacitance. This technique, used with triode valves in TRF radio sets, was popular in the 1920s and the neutralising feedback capacitors, called 'neutrodons', could be adjusted either by the user or a technician to prevent the RF (radio frequency) amplifiers oscillating.

In other circuit configurations, such as grounded base circuits or grounded collector circuits (emitter follower), the Miller effect is less of a problem because the transistor's collector and base are connected to low impedances. The cascode configuration eliminates it by keeping the lower transistor's collector voltage constant.

Another way of ameliorating the Miller capacitance is to use a relatively high collector voltage. That's because the feedback capacitance across the

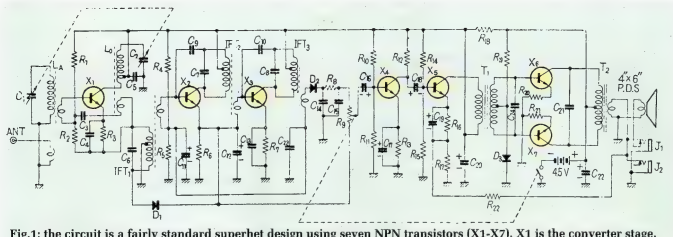


Fig.1: the circuit is a fairly standard superhet design using seven NPN transistors (X1-X7). X1 is the converter stage, X2 & X3 the first and second IF amplifiers, diode D2 the detector and X4-X7 the audio amplifier driver and output stages. The output stage (X6 & X7) operates in push-pull configuration, with diode D3 providing bias stabilisation.

reverse biased base-collector junction reduces with increasing voltage, much as it does with a varicap diode. This is why the world's first transistor radio, the Regency TR-1, used a 22.5V battery.

As transistor design improved, the 22.5V battery idea was dropped and lower voltage batteries made up from AA, C or D cells were used. The Sony TR72, for example, is powered from a 4.5V battery consisting of three D cells.

Later on, as transistor technology further improved, germanium RF transistors such as the AF115, AF125, OC171 and AF178 had collector-base capacitances that were so low they would work as IF amplifiers without any neutralisation. For example, the vintage OC45 germanium transistor has a Miller capacitance of about 10pF while for the more modern AF178, it's only about 0.8pF.

As another example, the vintage Eddystone EC-10 transistor communications radio uses OC171s in its IF amplifiers with no neutralisation at all.

Transistor radio advantages

One of the most remarkable features of simple 6 or 7-transistor radios is their very low current drain. Each transistor, except in the audio output stage, usually draws less than 1mA and the power delivered to the speaker is proportional to the volume setting.

In addition, the residual bias current for a transistor output pair running in class AB is usually in the order of 3-10mA at most. In fact, the total running current of the Sony TR-72 radio at a normal listening levels is about 10mA.

This means that with a set of 1.5V D-cells and normal daily use, the radio runs for months – completely unlike earlier valve radios which, depending on use, typically chewed through batteries in several days or perhaps a week or two.

Transistor radios also benefited from earlier developments with ferromagnetic materials. For example, the Meissner Company in the USA pioneered early examples of iron dust ferromagnetic cores in the late 1930s and these were used in their 1939 TV kitset: **www.worldphaco.com/uploads/THE_MEISSNER_5_INCH_KIT_AND_THE_ANDREA_KTE-5.pdf**

The later ferrite rod (or "magnetic bar") antenna works very effectively from 100kHz to about 12MHz and so was perfect for use as a compact antenna for the medium-wave 550-1700kHz band. This meant that AM transistor radios did not require a whip antenna and so they could be truly portable (or even pocket) devices.

Ferromagnetic core technology was also required to give high enough Q factors for the compact oscillator coils and IF transformers developed for use in transistor radios. It simply wasn't practical to use air-cored coils as they would need to be far too big.

So it wasn't just transistor technology that made compact transistor radios possible – the development of ferromagnetic material was also critical. This vital factor is often neglected in discussions about the evolution of the transistor radio.

Sony's TR-72 masterpiece

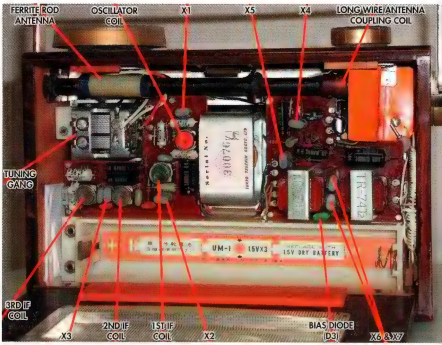
In typical Japanese fashion, Sony made just about everything for their radios in-house, including the transistors and diodes. Fig.1 shows the circuit of their TR-72 and it's interesting to look at the main features of what is a fairly standard single-conversion superhet design.

First, the transistors used in this radio are all NPN types. Most early commercial germanium junction transistors were PNP types and NPN germanium devices were rare, although it's worth noting that the Regency TR-1 transistor radio also used NPN devices.

If you have one of these radios and are stuck for a replacement transistor, an OC139 or OC140 will work, or perhaps even a 2SD11. There are also quite a few early 2SD series NPN germaniums which could act as replacements at a pinch.

Fortunately, in my TR-72 radio, all the transistors were still perfect. However, the detector diode had gone open circuit and so a germanium diode was neatly tacked across it. In addition, one of the primary wires on the audio output transformer had sheared off the bobbin, disconnecting the collector of transistor X6 and resulting in an asymmetrical and distorted audio output. As a result, the transformer was removed, the wire repaired and the transformer refitted.

Some of the circuit features are worth discussing. First, note that neutralisation capacitors C9 and C10 have been used in the IF stages for the reasons outlined above. However, there is no neutralisation required in the oscillator or "converter stage" based on transistor X1. That's because the tuned circuit at its collector runs at



This inside view of the Sony TR-72 shows the locations of the major components and the high standard of construction. Despite its age, the PCB and its various parts look almost like new.

the oscillator frequency and this is substantially different to the tuned RF signal frequency at its base. This in turn means that there is very little risk of signal being coupled from one circuit to the other. Also, the stage gain is low, so bandwidth is not an issue.

Conversely, in the IF stages, the transistor base and collector tuned circuits have the same frequency, hence the need for the neutralising capacitors (C9 & C10).

As stated, transistor X1 is the converter (ie, mixer/oscillator) stage and this type of converter is sometimes referred to as an "autodyne" converter. The oscillator frequency is varied by the tuning control (ie, variable capacitor C2, which is one section of a dual tuning gang). It runs 455kHz above the received frequency and the two frequencies are mixed to produce sum and difference products (ie, the sum and difference frequencies of the oscillator signal and the received station signal).

The 455kHz difference frequency is then passed by the first IF transformer primary (IFT1) which is tuned to 455kHz. This is called the IF (intermediate frequency) signal. It passes through IFT1 while other frequencies (including the oscillator and sum frequencies) are rejected.

However, there is another RF signal which could pass into the IF amplifier – that from a radio station broadcasting at exactly twice the IF frequency (ie, 910kHz) above the tuned station. This is known as the "image" frequency and it is also picked off by the 455kHz IF amplifier because it is exactly 455kHz above the oscillator frequency (thus resulting in another 455kHz difference frequency). However, due to the tuning of the ferrite rod's resonant circuit, the gain at the image frequency is low, so this isn't usually a problem.

Even so, a strong local station could still break through. For example, if the radio was tuned to 600kHz, a strong local station broadcasting close to 1510kHz could cause problems. The way around this is to have a highly-selective tuned RF stage which requires a 3-gang variable tuning capacitor. This type of arrangement appeared in transistor radios just a year later, eg, in the New Zealand-made Pacemaker Transportable radio. This radio looks similar to the TR-72 and will be described in a future column.

Following IFT1, the signal then passes through neutralised IF amplifier stages X2 & X3 and is then fed to detector diode D2. A negative AGC voltage is developed across C23 (on the secondary of IFT3) and this reduces the bias on X2 and X3 to lower the gain of the IF amplifiers in strong signal conditions to prevent overload.

Note that transistor X3's bias is derived from X2's, which saves adding another divider network. Note also that most of the voltage gain in a transistor radio (unless it has an RF stage) is in the IF amplifiers and it can be as much as 80dB for two stages.

There are two other clever circuit features here. First, the DC voltage across the base-emitter junction of X2 is used to provide a small amount of forward bias to detector diode D2. That's been done by connecting the

The TR-72 was housed in a sturdy timber case and this, combined with a 10 x 15cm loudspeaker, ensured relatively good bass response from the set. The volume/on-off switch (left) and tuning knob are at the top.

lower leg of the volume control to X2's emitter, which means that, from a DC perspective, D2's anode is at X2's base voltage. This helps in the detection of weak signals.

Secondly, under very high signal conditions, AGC diode D1 comes into play. It works like this: when the IF signal voltage is high, D1 conducts and charges capacitor C12. This decreases the bias applied to transistor X2, thereby lowering its gain, and also applies some reverse bias to detector diode D2. This helps prevent overload on strong signals.

Audio amplifier stages

The audio amplifier is quite standard and consists of pre-driver transistor X4, driver stage X5 and a transformer-coupled push-pull output stage based on X6 & X7. The output stage in turn drives the loudspeaker via another centre-tapped transformer.

The two coupling transformers are relatively large and combined with the good-sized (10 x 15cm) speaker and the ventilated timber case, give this radio quite a decent bass response. It's not at all like the 'tinny' sound that comes from many transistor radios.

Note the use of negative feedback via resistor R22 around the audio driver and output stages to lower distortion. The output transistors, which are not on heatsinks, are DC stabilised by 5Ω emitter resistors and "bias diode" D3. D3 tracks the variation in the base-emitter voltages of the output transistors with temperature and adjusts the bias to prevent thermal runaway.

Construction quality

An accompanying photo shows the inside view of this radio. The construction quality is remarkable and is practically unmatched by any modern consumer electronic device. Note that there is an additional coupling coil on the ferrite rod for a long-wire antenna. This is placed well away from the main tuning coil so that it has no effect on the tuning due to loading.

The cabinet appears to be made from a high-quality Japanese timber and the white Sony badge on the front is enamelled. The speaker mesh is made from anodised gold-colour expanded aluminium, while the back hinge assembly is made of brass.

Finally, all wires connect to the PCB via eyelets with solder tags and the transistors each have a good coat of paint. The overall quality is such that the inside of the radio looks as good as new after nearly 60 years! SC

Serviceman's Log – *continued from p43*

layer of dust covered the contacts, preventing them from conducting electricity, even at 230VAC.

I cleaned the switch contacts, reassembled it and tested it with my multimeter but it still didn't work. I dismantled it again and on closer inspection, discovered that the arm had been bent, probably due to some heavy-footed person actuating the unit. After straightening the arm and reassembling it again, I re-tested it and found that it now worked.

It was now time to put everything back together again. As I reassembled it, I cleaned the dust out of the various pieces and soon had it back together again. However, the dust collecting barrel had me somewhat puzzled. I'd reassembled it so that it was exactly the same as it was before I'd dismantled it but it just didn't look right.

In fact, it looked like there was a part missing, because the inner section was loose and there was a direct path between the vacuum intake and the suction from the motor, with no obvious filtering in between. As a result, I looked at this assembly more closely and then suddenly realised that it had been put together with the inner filtering unit upside down. So that explained why the inside of the cleaner had been full of dust.

Taking the inner filtering unit out and reversing it soon fixed that problem and meant that there was now a filter between the intake and the suction from the motor. I'm not sure why the previous owner had assembled it incorrectly, as they had bought it new and would have had the instruction manual that came with it. However, due to the design of the filter unit, it was in fact very easy to install it the wrong way around and cause the very problem I had just fixed.

So that was another useful piece of equipment repaired at virtually no cost, other than the time it took to dismantle, clean and reassemble it. However, it's very doubtful that this unit would have been taken on by a professional repairer, because it only cost $100 brand new. In short, if it broke down, it really was a "throw-away" item! SC

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HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER Front & Rear Panels	MAY 2012	21105122/3	$20 per set
MIX-IT! 4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
PIC/AVR PROGRAMMING ADAPTOR BOARD	JUNE 2012	04106121	$30.00
CRAZY CRICKET/FREAKY FROG	JUNE 2012	08109121	$10.00
CAPACITANCE DECADE BOX	JULY 2012	04106121	$20.00
CAPACITANCE DECADE BOX PANEL/LID	JULY 2012	04106122	$20.00
WIDEBAND OXYGEN CONTROLLER MK2	JULY 2012	05106121	$20.00
WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
SOFT STARTER FOR POWER TOOLS	JULY 2012	10107121	$10.00
DRIVEWAY SENTRY MK2	AUG 2012	03107121	$20.00
MAINS TIMER	AUG 2012	10108121	$10.00
CURRENT ADAPTOR FOR SCOPES AND DMMS	AUG 2012	04108121	$20.00
USB VIRTUAL INSTRUMENT INTERFACE	SEPT 2012	24109121	$30.00
USB VIRTUAL INSTRUMENT INT. FRONT PANEL	SEPT 2012	24109122	$30.00
BARKING DOG BLASTER	SEPT 2012	25108121	$20.00
COLOUR MAXIMITE	SEPT 2012	07109121	$20.00
SOUND EFFECTS GENERATOR	SEPT 2012	09109121	$10.00
NICK-OFF PROXIMITY ALARM	OCT 2012	03110121	$5.00
DCC REVERSE LOOP CONTROLLER	OCT 2012	08110121	$10.00
LED MUSICOLOUR	NOV 2012	16110121	$25.00
LED MUSICOLOUR Front & Rear Panels	NOV 2012	16110121	$20 per set
CLASSIC-D CLASS D AMPLIFIER MODULE	NOV 2012	01108121	$30.00
CLASSIC-D 2 CHANNEL SPEAKER PROTECTOR	NOV 2012	01108122	$10.00
HIGH ENERGY ELECTRONIC IGNITION SYSTEM	DEC 2012	04110121	$10.00
USB POWER MONITOR	DEC 2012	04109121	$10.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER (NEW V2 PCB)	DEC 2012	10105122	$35.00
THE CHAMPION PREAMP and 7W AUDIO AMP (one PCB)	JAN 2013	01109121/2	$10.00
GARBAGE/RECYCLING BIN REMINDER	JAN 2013	19111121	$10.00
2.5GHz DIGITAL FREQUENCY METER – MAIN BOARD	JAN 2013	04111121	$35.00
2.5GHz DIGITAL FREQUENCY METER – DISPLAY BOARD	JAN 2013	04111122	$15.00
2.5GHz DIGITAL FREQUENCY METER – FRONT PANEL	JAN 2013	04111123	$45.00
SEISMOGRAPH MK2	FEB 2013	21102131	$20.00
MOBILE PHONE RING EXTENDER	FEB 2013	12110121	$10.00
GPS 1PPS TIMEBASE	FEB 2013	04103131	$10.00
LED TORCH DRIVER	MAR 2013	16102131	$5.00
CLASSIC DAC MAIN PCB	APR 2013	01102131	$40.00
CLASSIC DAC FRONT & REAR PANEL PCBs	APR 2013	01102132/3	$30.00
GPS USB TIMEBASE	APR 2013	04104131	$15.00
LED LADYBIRD	MAY 2013	08103131	$5.00
CLASSIC 12V to ±35V DC/DC CONVERTER	MAY 2013	11104131	$15.00
DO NOT DISTURB	MAY 2013	12104131	$10.00
LF/HF UP-CONVERTER	JUN 2013	07106131	$10.00
10-CHANNEL REMOTE CONTROL RECEIVER	JUN 2013	15106131	$15.00
IR-TO-455MHZ UHF TRANSCEIVER	JUN 2013	15106132	$7.50
"LUMP IN CHUNK" PORTABLE MIXER	JUN 2013	01106131	$15.00
LIL PULSER MKII TRAIN CONTROLLER	JULY 2013	09107131	$15.00
LIL PULSER MKII FRONT & REAR PANELS	JULY 2013	09107132/3	$20.00/set
REVISED 10 CHANNEL REMOTE CONTROL RECEIVER	JULY 2013	15106133	$15.00
INFRARED TO UHF CONVERTER	JULY 2013	15107131	$5.00
UHF TO INFRARED CONVERTER	JULY 2013	15107132	$10.00
IPOD CHARGER	AUG 2013	14108131	$5.00
PC BIRDIES	AUG 2013	08104131	$10.00
RF DETECTOR PROBE FOR DMMs	AUG 2013	04107131	$10.00
BATTERY LIFESAVER	SEPT 2013	11108131	$5.00
SPEEDO CORRECTOR	SEPT 2013	05109131	$10.00
SIDRADIO (INTEGRATED SDR) Main PCB	OCT 2013	06109131	$35.00
SIDRADIO (INTEGRATED SDR) Front & Rear Panels	OCT 2013	06109132/3	$25.00/pr
TINY TIM AMPLIFIER (same PCB as Headphone Amp (Sept'11))	OCT 2013	01309111	**$20.00**
AUTO CAR HEADLIGHT CONTROLLER	OCT 2013	03111131	$10.00
GPS TRACKER	NOV 2013	03112131	$15.00
STEREO AUDIO DELAY/DSP	NOV 2013	01110131	$15.00
BELLBIRD	DEC 2013	08112131	$10.00
PORTAPAL-D MAIN BOARDS	DEC 2013	01111131-3	$35.00/set
(for CLASSIC-D Amp board and CLASSIC-D DC/DC Converter board refer above [Nov 2012/May 2013])			
LED PARTY STROBE (also for Hot Wire Cutter [Dec 2010])	JAN 2014	16101141	$7.50
BASS EXTENDER MK2	JAN 2014	01112131	$15.00
LI'L PULSER Mk2 Revised	JAN 2014	09107134	$15.00
10A 230VAC MOTOR SPEED CONTROLLER	FEB 2014	10102141	$15.00
NICAD/NIMH BURP CHARGER	MAR 2014	14103141	$15.00
PRECISION 10V REFERENCE	MAR 2014	04104141	$5.00

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Send your email to silicon@siliconchip.com.au

Lower power ignition coil for Jacob's Ladder

For the Jacob's Ladder project described in 2013, would using a generic 12V automotive coil and not a Commodore VN coil, result in orange sparks not moving up the wires but staying at the bottom where the clips attach to the coil? (J. E., via email).

● We described a Jacob's Ladder using a conventional coil back in September 1995. Have a look at that article to see how we used an insulating terminal block to set the minimum gap. It worked but the spark display was not as hot as with the Commodore coil.

5A current regulator required

This question regards your excellent article on the MiniSwitcher (SILICON CHIP, February 2012) which is also available as a kit from Altronics (Cat. K6340) and Jaycar (Cat. KC5508). Is it possible to reconfigure the circuit to operate as a constant current switching regulator, much like what can be done with conventional 3-terminal linear regulators? I'm guessing it's possible to remove VR1 and instead use a suitable current sense resistor on the power supply return.

As a second part to this question, my particular application requires delivering about 5A to a load, with a control pot for fine tuning. Unfortunately, this current is much higher than the ~1.5A limit of the circuit in the article. Is there an easy way to extend the current rating of the circuit, perhaps by using output pins 5 & 6 of the AP5002 to somehow gate an external MOSFET? Alternatively, is there another suitable SILICON CHIP article you can refer me to? (M. C., via email).

● Most switchmode regulators can be reconfigured to act as current sources however there is no easy way to get a 1.5A regulator to deliver 5A. It can be done but you might as well just start with a device designed to supply that sort of load. Have a look at the LED Dazzler, which is a discrete switchmode current regulator. You can preview it at: **www.siliconchip.com.au/Issue/2011/February/LED+Dazzler%3A+A+Driver+Circuit+For+Really+Bright+LEDs**

It has a potentiometer for adjusting the current over a wide range and was originally intended to deliver up to 3A, to drive multiple LEDs in series (and thus this can give a pretty high power output) but it should work OK at 5A. Use a 5A inductor for L1 (there should be room) and use 0.05Ω for R1 (eg, by stacking and paralleling two 0.1Ω 5W resistors).

You might also want to use higher-value, lower-voltage low-ESR capacitors (depending on what supply voltage you plan on using) but otherwise it should be OK as it is.

We can supply a PCB for this project but there is also a kit available from RMS Parts – see their website at: **http://rmsparts.com.au/prodDetail.ews?stock.ewdcat=Kits&stock.ewdcategory2=LED%20Kits&&stock.ewdid=4513**

LED light source for orchid propagation

My son grows orchids from seed. The babies grow in sterile conditions in a nutrient agar solution in flasks. He has set up strips of LEDs to supply the necessary light in our spare bedroom.

My query is regarding powering these LEDs. According to my simple bench power supply, each LED strip is drawing around 800mA. If he needs to power 40 strips then I'm assuming

Frequency Switch Is Sensitive To Signal Waveform

I recently built the Frequency Switch project (SILICON CHIP, June 2007) to operate a dual-port manifold on a V8 engine at around 3000 RPM. I found I get a "false signal" at around 1000 RPM, depending on the load on the engine; the more load the greater the false signal. That signal goes away around 1100-1200 RPM and the switch operates as it should at the 3000 RPM setting, although the 3000 RPM setting does vary with the load as well. More load lowers the RPM at which the switch operates.

I am using the same signal as is used for the tachometer that comes from coil negative. What could be going on and how can the "false signal" be eliminated? Could a high-pass filter be used on the input to eliminate this false signal and what value capacitors and resistors would be suitable? (L. H., Miranda. NSW).

● Since you are taking the signal directly from the ignition coil, then the wave shape will vary depending on engine load. That is because the spark will vary in intensity and duration, depending on the pressure within the cylinder and this will be reflected in the coil's negative primary winding. It would appear that the ignition coil primary voltage is ringing when the spark developed is under load, producing a higher frequency than the actual spark rate.

You should be able to better filter the coil waveform by increasing the value of the 10nF capacitor connected across 16V zener diode ZD1 at the signal input section of the Frequency Switch circuit. You could try a 100nF capacitor or a value between 10nF and 100nF, eg, 47nF. Note that if the capacitor is increased too much, the frequency switch may not work at 3000 RPM.

In addition, the 10kΩ input resistor should be a 1W type to handle the high voltage from the primary winding of the ignition coil.

Bow Thruster Speed Controller Wanted

I have been reading with interest the article in the February 2014 issue on the Intelligent Speed Controller. I am toying with the idea of a speed controller for the bow thruster on my boat.

The major problem is that the thruster draws up to 550A at 12V DC. Currently, the thruster is either on or off. Speed control would greatly improve its operation. My thoughts are along the lines of an IGBT module controlled by the front-end of your Speed Controller. As well, I am going to build a PIC controller to ensure that there is a delay during a quick change-over from side to side plus monitor temperature and turn the system off after a period of inactivity.

Could you offer any comments or suggestions that might assist please? (G. C., via email).

● Leo Simpson comments: I am surprised that you want a speed controller for a bow thruster. I have a fly-bridge cruiser with bow and stern thrusters and they both draw extremely large currents, as does yours. However, I have never felt the need for any sort of speed control. I just give it the briefest of nudges in one direction or the other, to point the boat where I want it (mainly when reversing into the berth or when picking up a mooring).

In fact, the thrusters should be used only in the briefest of bursts because they can quickly overheat, as well as quickly discharge even the most rugged of batteries.

I do have the benefit of twin motors so I can also use combinations of props in forward and reverse gear for very fine control, without any need of thrusters. In fact, with judicious control of rudder, throttle and prop direction, it's possible to move the boat sideways. I would normally only use the thrusters when wind and current conditions make it awkward to safely manoeuvre a boat in close quarters. This is particularly the case when the wind is fluky or gusting severely.

The very large currents involved with thrusters would also present a major engineering exercise to make it reliable while ensuring very little voltage drop and minimum power loss in the controller IGBTs. We really don't think it would be a viable project.

Your ideas for a temperature monitor and time-out switch-off after inactivity are good. Commercial installations typically incorporate time-out plus an audible alarm to tell you it is about to switch off.

This is important because it could be very awkward if you go to use the thrusters and they have been switched off.

a 40A switchmode supply from Jaycar will do the job. But what would be the ramifications of running the 40 strips on a 20A switchmode supply?

If I was to run 6A worth of LEDs on a simple transformer and bridge rectifier capable of putting out 3A, I assume there would be no problems with overload of the power supply; it would simply run at its maximum of 3A and the LEDs would not be as bright. Do switchmode power supplies operate in the same way in this respect? Or would the 20A switchmode supply try to over-exert itself and burn out?

At this stage, he is intending going with the 40A supply but there's every chance in the future that more shelves, and therefore more LED strips, will be added to the room, resulting in the supply running at or over its maximum rating. (B. L., via email).

● Normally, you can expect a switchmode power supply to shut down if overloaded. But why take the risk because it is possible that a severe overload might cause permanent damage? Such damage is not likely to be easily repaired.

A simple transformer, rectifier and filter supply would drop in voltage and the transformer would overheat if overloaded. In your example, running a 6A load on a 3A supply, the supply would not just deliver its 3A rating, but would drop in voltage level with the increased load.

Even so, overloading a conventional power supply beyond its ratings can either blow the fuse or permanently damage the supply. It is not a good idea to depend on overload protection in normal operation.

Why are hearing aids so expensive?

The people at the Audio Clinic tell me that a basic hearing aid for me would cost about $4000 whilst one more suitable (cuts out extraneous noises, etc) would cost about $6000. Why are these so expensive? Surely the technology in a standard phone or PC is far more complex than a hearing aid but costs a fraction of the price? It's possibly a matter of numbers, production etc but it still seems way out of proportion. (G. B., Emerald, Vic).

● We agree! Even taking into account the miniaturisation (and therefore precision) in a modern hearing aid, in the vast majority of cases we are being seriously overcharged. Back in the July 2011 issue, we published a review after testing a pair of new hearing aids from a company then called "Australia Hears" (they've since changed their name to Blamey and Saunders Hearing). These hearing aids worked extremely well and our reviewer, who was quite deaf in one ear and marginal in the other, found he was hearing sounds he had not experienced for at least 40 years!

Following this, Blamey and Saunders asked us to review a pair of their new "digital" hearing aids, which were even better performers. That review was published in the March 2013 issue of Silicon Chip.

Our reviewer had a similar experience to yours. He'd been told that a decent pair of hearing aids would cost him over $10,000. But the hearing aids reviewed at the time cost less than $1000 each. Even today, the newer digital models sell for only $1980 per pair. We'd suggest you visit their website at www.blameysaunders.com.au and see for yourself.

New regulator wanted for a Honda motorcycle

I have a 1982 Honda FT500 Ascot motorcycle and I'm in the throes of designing a new ignition system for it. I also got the idea that I could replace the old-style shunt regulator/rectifier with a modern-design SCR or Triac type regulator. I'm climbing the learn-

Advice On Class-D Home-Theatre System

I would like to build three class-D amplifier kits into my home-theatre system to drive front right, left and centre speakers from a Pioneer VSX-D811S receiver. How would I configure it? One transformer, one bridge rectifier, one or two power supply modules and one or two speaker protector modules? Do I need potentiometers on the input signal?

Could you suggest a suitable case? The ones I have seen have a front panel which is wider than the case itself. (J. C., via email).

● For the left-centre-right speaker arrangement, a single 300VA transformer supply would be suitable for all three amplifiers, with the left and right channels set in anti-phase to average out the current drain.

You should use two speaker protectors to provide for protection of the three outputs.

Altronics sell rack cases with detachable side ears. These are Cat. H5045 and Cat. H5047 and you can check them out at www.altronics.com.au

The volume would normally be controlled by the receiver. However, a pot or pots could be fitted to set the initial ratio of left/right to centre channel volume.

ing curve on Arduinos and I thought I might go that route.

The Ascot's electrical charging system is plain-vanilla with a 3-phase output from a permanent magnet alternator. I believe the peak voltage is around 30VAC. At present, this goes into a shunt regulator/rectifier that delivers the typical 13V DC with a peak voltage of around 14.2V DC experienced. Peak amperage is around 20A DC.

Have you guys ever published a modern design for a 3-phase voltage regulator/rectifier for 12V DC power delivery? (G. N., via email).

● We have not published a regulator for a motorcycle alternator. A shunt regulator is necessary for this type of generator as the voltage generated can reach very high values with a light load. The permanent magnet alternator means that there is no control available of the field and so shunting the output is the only practical way to control the output voltage.

And while a shunt regulator can be wasteful, it is effective at low engine RPM because it does not place any load on the alternator. This is in contrast to any series regulator which inevitably has losses across the series element.

PortaPAL-D batteries could use single cells

I like the extensive battery protection in the PortaPAL-D (Silicon Chip, December 2013, January & February 2014). I see how the battery management protects the Li-Po cells during the charge process and the 12V monitoring could also protect an SLA battery during the discharge process.

I was just wondering how easy it would be to use discrete cells instead of a pre-built Li-Po pack in this project? This could be a cheaper method. If the weakest cell could then be identified and replaced at the end of its life, this could save even more money (and the environment) by keeping the remaining healthy cells in service for some more time.

I hate to think how many Li-Po packs have already been replaced just because a single cell has failed. Maybe I am wrong and a cell failure is an indication that all cells are near their end of life. (P. S., via email).

● You could use individual cells. The cell monitoring wiring and connector would need to be incorporated so that the charger can monitor each cell as it does with a battery pack.

Delay circuit wanted for relay control

Can the Car Courtesy Light Delay project (Silicon Chip, June 2004) be wired as a delay turn-off for a 12V relay with a 285-ohm coil? (G. C, Gold Coast, Qld).

● No. This is intended to control low-voltage interior lamps in cars. Specifically, it is intended to work with the low "cold resistance" of an incandescent lamp when it is off. It is this low resistance that allows the circuit to be charged up before the lamp switches on. Then the lamp is dimmed over time.

This won't work with a relay as its initial resistance is too high to charge the circuit fully. The 'dimming' action would cause the relay to switch off as the voltage drops below its holding voltage. The relay contacts could wear more if there is high current through the contacts as the relay coil is slowly reducing contact pressure around the contact's holding voltage.

In addition, the circuit does not have

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Silicon Chip magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of Silicon Chip magazine.

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HDMI Sound Decoder Wanted

Is there any chance to see a design for an HDMI sound extractor? I have an old but still very good amplifier that takes in 5.1 surround sound via six RCA plugs and drives five speakers plus a subwoofer.

In the past, I used it to watch movies from my VCR and the sound was just fantastic. A few years ago I replaced my VCR with a DVD player but could only get stereo sound. I plan to replace my DVD with a Blu-ray player but all players now come with only HDMI, optical and maybe 2-channel audio outputs. No more 5.1 surround sound!

I understand that HDMI carries eight channels of uncompressed audio, on top of video. I would like to see a device that takes the HDMI signal from the player and sends HDMI (video only) to the TV and 5.1 surround sound via six RCA plugs to the amplifier.

Jaycar carries something of the sort (HDMI Audio Extractor, Cat. AC-1637) but the sound output is only 2-channel. The people at Jaycar tried to persuade me that I could get surround sound with only two wires! I do not believe that. I think all I would get would be simulated surround sound; my amplifier already does that! Or are the people at Jaycar correct?

Could you please investigate if such a device is possible? Would it be possible to modify the existing Jaycar device? (P. Q., via email).

● It is very difficult to design a project to extract audio signals from HDMI. Obviously it can be done but they have gone to great lengths to make it all but impossible to do (via schemes like HDCP – High Definition Copy Protection).

We'd also need to pay license fees to Dolby and DTS in order to decode the compressed audio. The license fees are required in order to decompress the patented AC3 and DTS compressed multi-channel formats and derivatives. There is free software to do this decoding but we are not sure about the legality of using it in Australia without paying the fees.

Even if it was legal, it would be very difficult for us to design a surround sound decoder that you could build for anything like what they charge for the linked unit below (about $60 including delivery).

You are right that the Jaycar unit won't do the job. It will extract multi-channel sound from HDMI but this will only be available on the digital outputs; the two analog outputs will likely carry a stereo down-mix.

The best solution seems to be to get a device which will take the optical (TOSLINK) output from your Blu-ray player and split it into the six analog channels. For example, see www.aliexpress.com/item/New-Digital-Audio-Decoder-5-1-Audio-Gear-DTS-AC-3-6CH-Digital-Audio-converter/1352699484.html It has multiple inputs and you can switch between them.

The outputs appear to be three 3.5mm stereo jack sockets so you just need three stereo jack socket to RCA leads to make connections to an amplifier.

any protection to cope with the switch-off spike from the relay coil. We suggest that you use the Flexitimer project from *Electronics Australia* (Jaycar KA-1732) or the later SILICON CHIP version from June 2008 (Jaycar KC-5464).

Cooling the Induction Motor Speed Controller

Do you think it would be a good idea to use two fans instead of one for the Induction Motor Speed Controller or do you think it would be overkill for the amount of heat generated? (T. J., via email).

● More cooling is generally better although just having one fan is probably sufficient. You could use two fans although you may be better off just using one and running it at a higher speed or alternatively, using a single fan with a larger diameter. However fitting two fans has the advantage that you can run them both off the low-voltage supply.

If you're using one fan to suck air into the case and one to blow air out the other side, that could be effective to promote airflow across the heatsink fins but you will have to check to make sure that this doesn't set up flows which allow a significant proportion of the air to bypass the heatsink. One way to be sure would be to measure heatsink temperature during normal operation. If it seems a little high with just one fan installed, there is nothing to prevent you from fitting a second fan.

Recheck switch wiring to prevent burn-out

I've had the Courtesy Light Delay For Cars kit in my car for some time. One day I was replacing the door switches and smoke came out of the module. I opened it up and the STP16NF06 Mosfet was burnt out. I replaced it and it burnt out straight away when I plugged the module back in.

Would this be due to a bad door switch earth? The component burnt out on the negative door input side (S. H., via email).

● We cannot say why the circuit would have been damaged. Just replacing the door switches should not have damaged it. Maybe the wiring is now different, with the Courtesy Light Delay unit connected across the courtesy lights instead of the switch.

We can only suggest that you recheck the switch wiring. Maybe the switches are not quite the same as the original arrangement.

Adding intelligence to a dumb clothes dryer

I have a "dumb" clothes drier with two heat settings and a mechanical timer. Is it worthwhile having some electronic smarts to intercept the internal wiring for the following purposes

(1) humidity sensor to stop the drier when sufficiently dry (good power saving here)?

(2) digital temperature control for sensitive fabrics?

(3) motor reversing option to stop the tangles, commonly called wrinkle guard?

Possibly this would be a good Arduino project? (C. D., via email).

● Your ideas are all good but they would require quite a lot of electronics. Currently, some modern clothes dryers feature humidity sensing and/or motor reversing but these features

Notes & Errata

Timer For Fans And Lights (August 2012): do not wire the unit up as shown in Fig.1(c) on page 65, with a load from the "Asw" terminal to Neutral. This will destroy the unit. If you need to wire up a fan and light, connect them in parallel between the "Aload" terminal and Neutral.

230V 10A Universal Motor Speed Controller, February 2014: a 100nF MKT polyester capacitor was omitted from the circuit and parts list (there should be five, not four). It connects between the wiper of VR3 (pin 2 of IC1) and ground. The PCB pattern and the PCB overlay published in this issue are correct. The capacitor is immediately adjacent to CON10.

Mini Entertainment Unit, February 2014: the modified version of the MiniReg Adjustable power supply (pages 46 & 47) should specify a higher-rated diode for D1, to match the current rating of the LM338 adjustable 3-terminal regulator. We suggest a BY229 fast switching diode. It has low forward voltage and a current rating of 8A. It comes in a TO-220 package which can be mounted upright on the PCB.

Stereo Echo & Reverb Unit, February 2014: on page 35, the article states that this unit can be built from a delay unit kit (Jaycar KC-5506). Unfortunately, this kit is for the delay unit from December 2011 rather than November 2013 and is not suitable.

SILICON CHIP can supply the PCB, programmed microcontroller and some of the parts for this project; see our Online Shop ad or website for more details.

would be difficult to incorporate in a dumb dryer. In particular, the drum and dryer are typically powered by a single-phase induction motor and these are usually not possible to reverse, even if you have access to the internal wiring.

Most modern dryers do have a 2-way switch to control the power level and that is probably all that is required to protect delicate fabrics.

Humidity sensing of the exhaust air is a good idea but you would need to ensure that the humidity sensor never became clogged by the residual lint which is always present.

Battery load tester wanted

In May 2011 you published an "electronic solar panel" for want of a better name, in other words a supply that acted like a solar panel for testing solar regulators. I am wondering if you have ever produced what can only be called an "electronic battery" for testing battery chargers. I specifically refer to lithium-ion chargers which have tight requirements for voltage sensing in particular.

What I envisage is an active load which will sink a known and adjustable current while presenting a known and adjustable terminal voltage to the source; in other words, "look" just like a battery under charge so that cut-off points etc can be checked. (I. M., via email).

● In the past, we have built several prototypes of what could be called "adjustable loads" or adjustable current sinks but they did not make it to publication because of various problems with thermal stability and supersonic oscillation. In each case, they were based on power Mosfets.

It is a tricky design exercise, made more difficult if the design has to cope with a wide range of battery voltages and load currents.

MPPT controller needs RF suppression

I do realise that the MPPT Solar Charge Controller from the February 2011 issue and its update in the March 2012 issue have been around for awhile but I need to ask this question anyway. While it works exactly as it should, my problem with it is the amount of switching noise it generates. It creates 31.5kHz birdies from the bottom end of the AM broadcast band to at least 7.5MHz.

This is not good for amateur radio use! I have tried some brute force filtering (a Pi filter with a 10mH choke and two 10,000µF capacitors on the input and output of the controller) but so far I have been unsuccessful in making any difference to the noise level.

Any advice pointing me in the right direction would be much appreciated. (A. B., via email).

● While we have not tried it, the metal case could be connected to the battery negative screw terminal using an eyelet screwed to the box and a wire lead. Then use ferrite suppression clip-on sleeves over the solar panel and battery wiring. The Jaycar LF1290, LF1292 or LF1294 (or similar) ferrite suppression sleeves could be used.

Questions on ADSB collinear antenna

I really liked your down-to-earth article on ADSB antennas in the September 2013 issue and I would like to ask a few questions. Was either antenna tested for performance and return loss etc? If so, what were the results? What is the anticipated bandwidth of each type of antenna design? What is the dielectric effect of putting the 1090MHz collinear in PVC piping? What tools would be needed to tune the antennas, if needed. I'd like to get optimum performance from the collinear design. (J. G., via email).

● The antennas were only checked for signal pick-up. No other parameters were checked.

We would not expect any dielectric effects from the PVC piping and no effect on signal pickup. Countless antennas these days are housed in some sort of plastic sheathing and it does not effect pick-up.

Unless you have equipment to measure signal pick-up such as a spectrum analyser, it would be difficult to tune or optimise the antenna.

MPPT controller only designed for solar panel

I recently completed the MPPT solar panel charger for use with a small camper van and all works fine. It is the upgraded second version featured in the March 2012 issue. However, the rest of the electrical system needed an overhaul.

A regulated mains power supply is set to produce 13.3V and this is permanently connected to the battery in normal use. Clearly, this system will never be able to fully charge the battery

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and what's more, it has a small drain and consequently the battery slowly discharges when the van is not in use.

So it seemed reasonable to increase the output of this power supply and connect it in parallel with the solar panel input (120W) to the MPPT, using a Mosfet as a protection diode in the power supply's output. I guessed at setting the power supply output to 17V since this is just below what the panel would produce when charging via the MPPT. It was not my intention to have both power supply and panel charging simultaneously although it will depend on the software as to whether this will be OK.

In fact, the input to the MPPT from the panels is 15.8V during bulk-charging and this seems to charge the battery more quickly than using the power supply. The results were interesting. Using the power supply, the MPPT Controller went into bulk charging mode as expected but the bulk charging LED flashed off briefly about every four seconds.

In the description, it says that if the battery voltage is lower than 10.5V, the MPPT will charge in bursts with the LED flashing every four seconds before bulk charging begins. By this I presume that flashing means it is on briefly every four seconds but in this case, it is off briefly every four seconds. In fact, the battery voltage was around 12V so perhaps this is a coincidence.

So is my arrangement to have the power supply charge the battery via the MPPT Controller reasonable? What could be the reason for the brief flash off every four seconds until bulk charging ends ? (D. W., via email).

● The MPPT Charger assumes that a solar panel is connected rather than a power supply. If using a power supply instead of a solar panel, it would be

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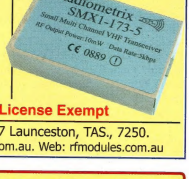

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best to use a current-limited supply set for around 6.6A and at 18V. That is because the MPPT charging works on the fact that the current will drop as the solar panel is loaded. The solar panel output follows the VI curve as shown in Fig.1 of the February 2011 issue.

The flashing of the LED during bulk charging indicates the way the MPPT system works. This system periodically checks the panel to set the circuit up for maximum power transfer. The LED indicates when this is happening.

Queries on the Jacob's Ladder

My son and I are looking at building the Jacob's Ladder Mk3 (Silicon Chip, February 2013) project together and among other things, learning how it works. I have a few questions as this is our first foray into high-voltage electronics. What is the minimum safe distance from the electrodes that one can safely enjoy the arc without a decent acrylic tube barrier?

While the project recommends a car battery, after a scan over the circuit diagram, could the project be run from a 12V 5A (or better) DC power supply? And how long can the ladder be in operation before it overheats, if it overheats? (A. F., via email).

- The spark voltage will jump across a 30mm gap. If the gap is made too large, the spark will simply jump across the terminals of the coil itself. However, you should avoid putting your hands or any other body part within about 10cm of the spark wires, merely to avoid the possibility that you might inadvertently go too close and come into contact. If you do that, you won't do it again!

A power supply capable of more than 5A would be needed; preferably 8-10A. The unit should not overheat, even if it is used continuously. After all, this unit is merely a variant of our ignition system which is intended for continuous use in the engine bay of a vehicle.

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Super Jacob's Ladder with two transformers

I would like to connect the outputs of a 15kV neon transformer to the output of a 10kV oil fire transformer to produce a 25kV Jacob's Ladder. Would this be OK or would I need high-voltage diodes to stop feed from one transformer getting into the other transformer? If so, what diodes would I need? At the moment I have two Jacob's Ladders but would like to boost it up if possible. (A. F., via email).

- You can connect the two secondary windings of your transformers together to get a theoretical total of 25kV. However, you must do it so that the voltages add instead of subtract (there the result would be only 5kV).

In effect, you have it connect the start of one secondary winding to the finish of the other. Since there is probably no easy way of identifying the starts and finishes, you would have to do it by trial and error. If you get it right, the total voltage will jump a much bigger spark gap than it otherwise would.

However, you should remember that the maximum output voltage you actually obtain will depend on the dimensions of the spark gap in the ladder and the insulation of all the wiring leading from the transformers to the Ladder itself.

Even so, the resulting Jacob's Ladder display will be limited by the less powerful transformer. In practice, the display might not be any better than that produced by the high-energy ignition coil we employed in the Jacob's Ladder featured in the February 2013 issue. And since it is battery-powered, we think it would be safer than your transformer-powered version. SC

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